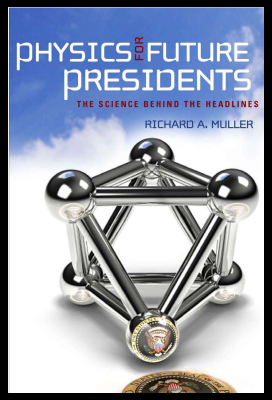
Physics for Presidents and other World Leaders



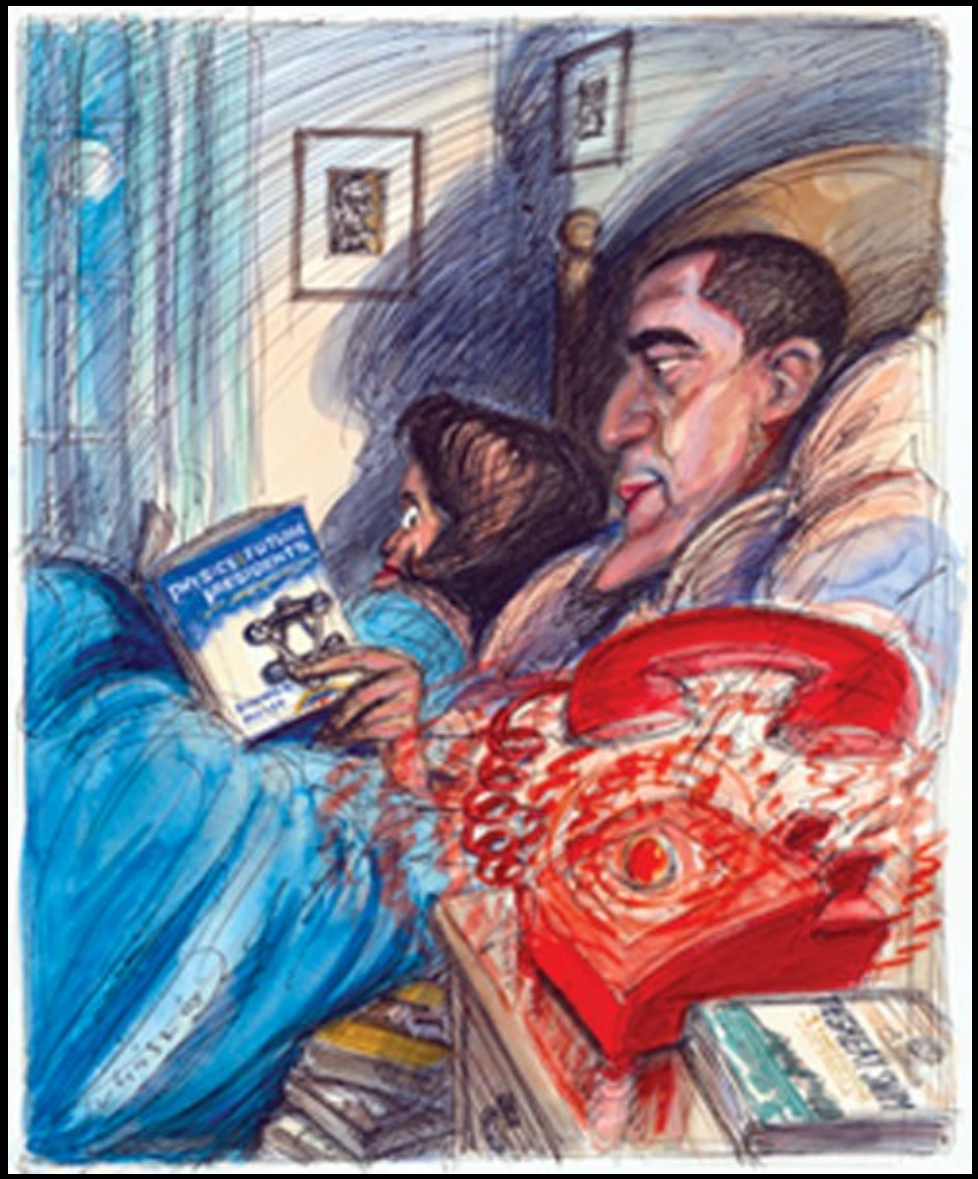
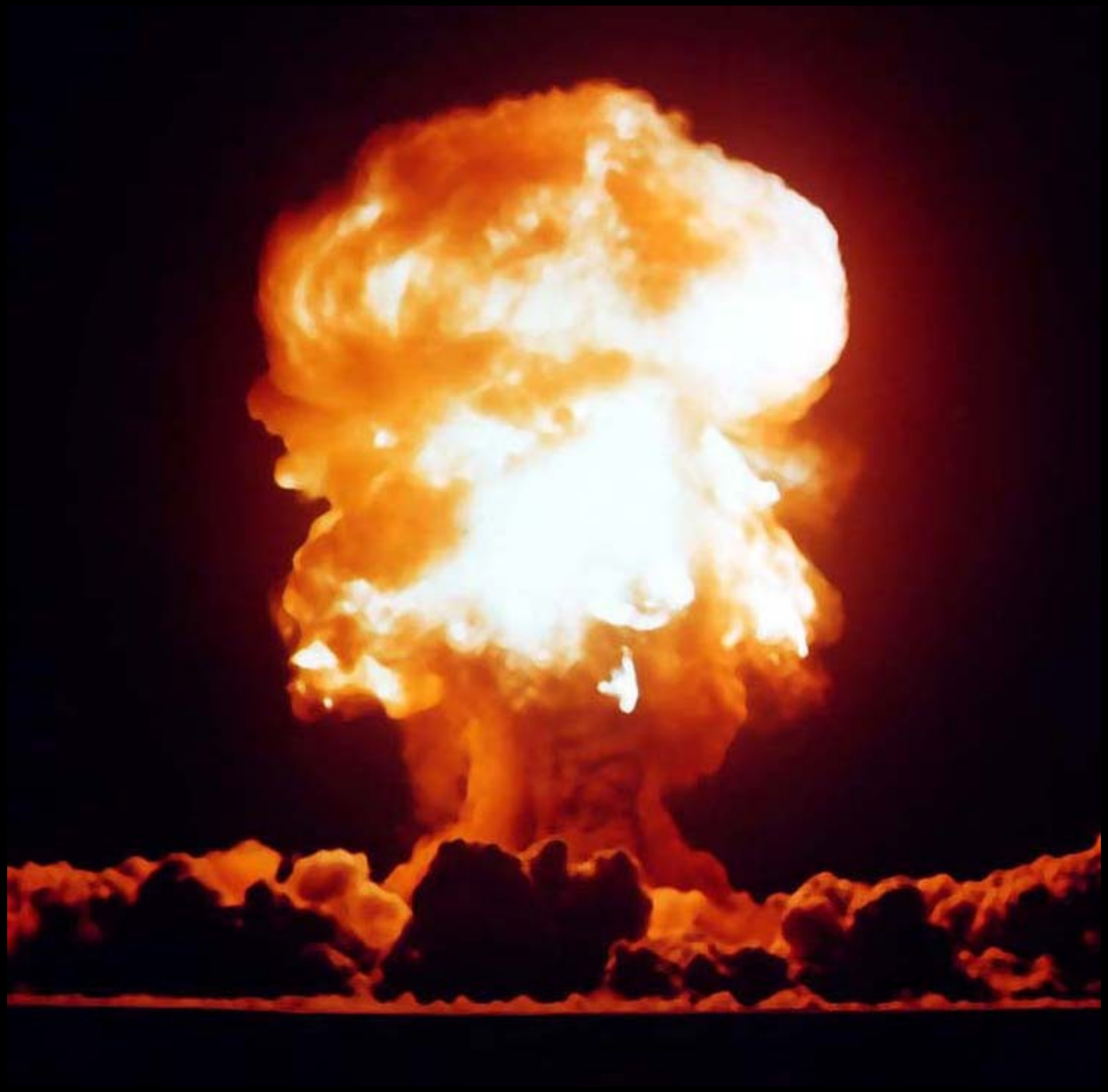
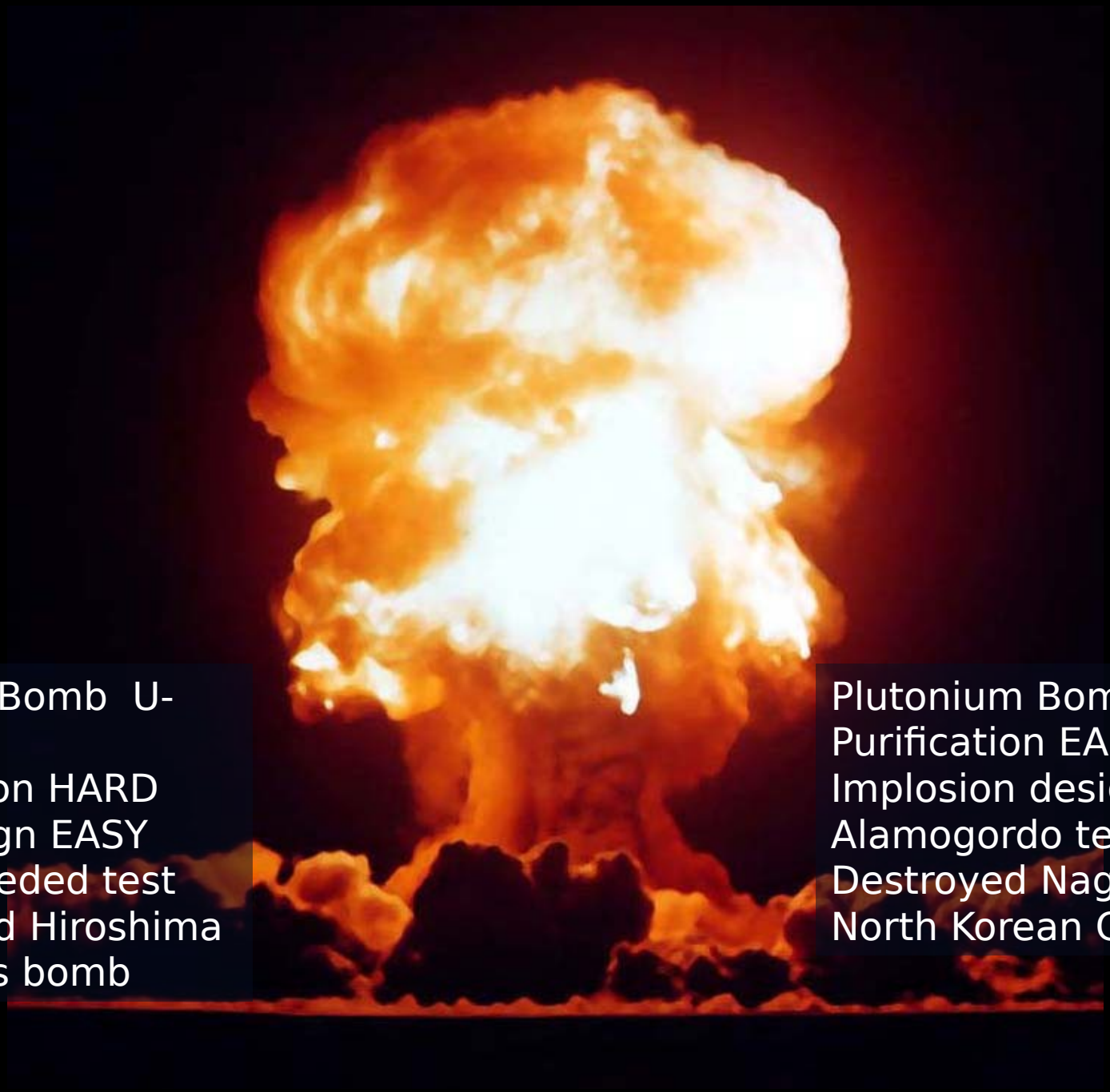


photo by Victor Juhasz

Today:

- terrorism
- nuclear weapons
- energy
- climate change

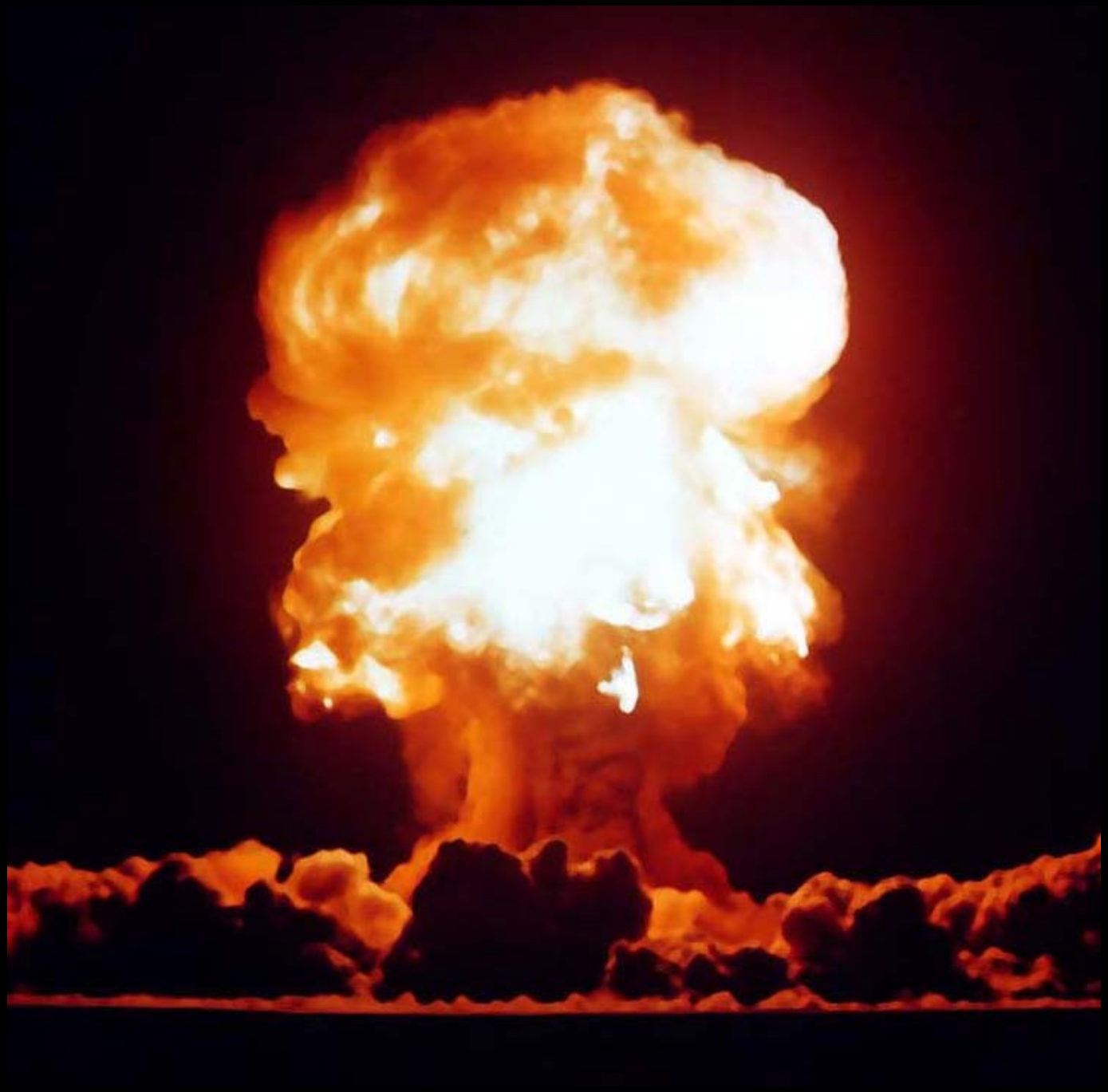




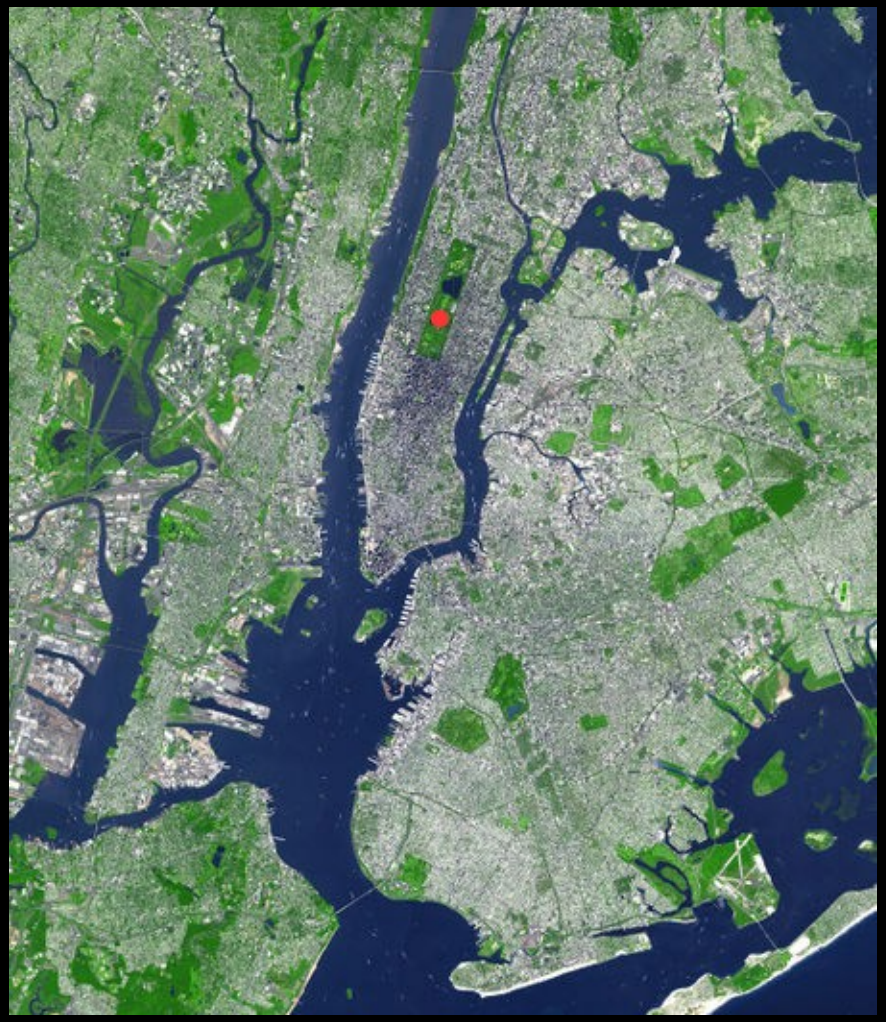
Uranium Bomb U-235
Purification HARD
Gun design EASY
Never needed test
Destroyed Hiroshima
Saddam's bomb

Plutonium Bomb Pu-239
Purification EASY
Implosion design HARD
Alamogordo test
Destroyed Nagasaki
North Korean Choice

Saddam's Calutrons

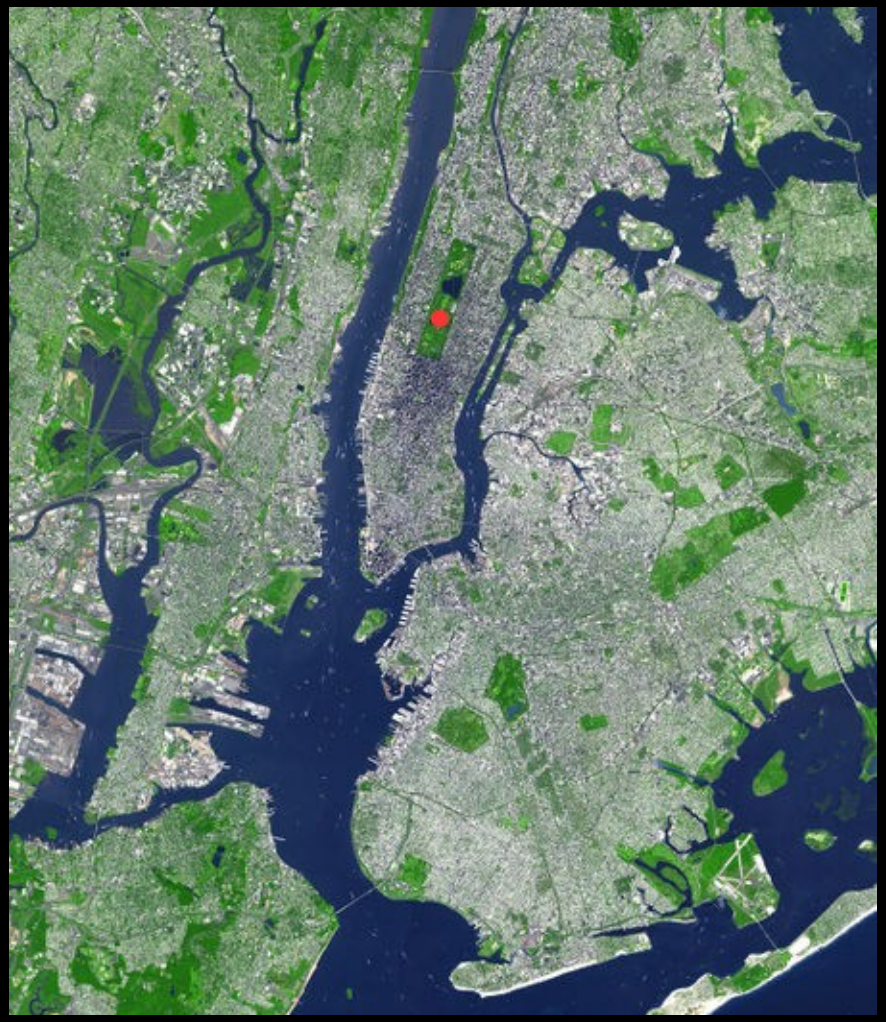


North Korean Nuke hits Central Park



1 Megaton Nuke hits Central Manhattan

North Korean Nuke hits Central Park



9/11

Energy per gram

object	Calories (or Watt-hours)	joules	compared to TNT
bullet (at sound speed, 1000 ft per sec)	0.01	40	0.015
battery (auto)	.03	125	0.05
battery (rechargeable computer)	0.1	400	0.15
battery (alkaline flashlight)	0.15	600	0.23
TNT (the explosive trinitrotoluene)	0.65	2,723	1
modern High Explosive (PETN)	1	4200	1.6
chocolate chip cookies	5	21,000	8
coal	6	27,000	10
butter	7	29,000	11
alcohol (ethanol)	6	27,000	10
gasoline	10	42,000	15
natural gas (methane, CH_4)	13	54,000	20
hydrogen gas or liquid (H_2)	26	110,000	40
asteroid or meteor (30 km/sec)	100	450,000	165
uranium-235	20 million	82 billion	30 million

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US Cost of energy

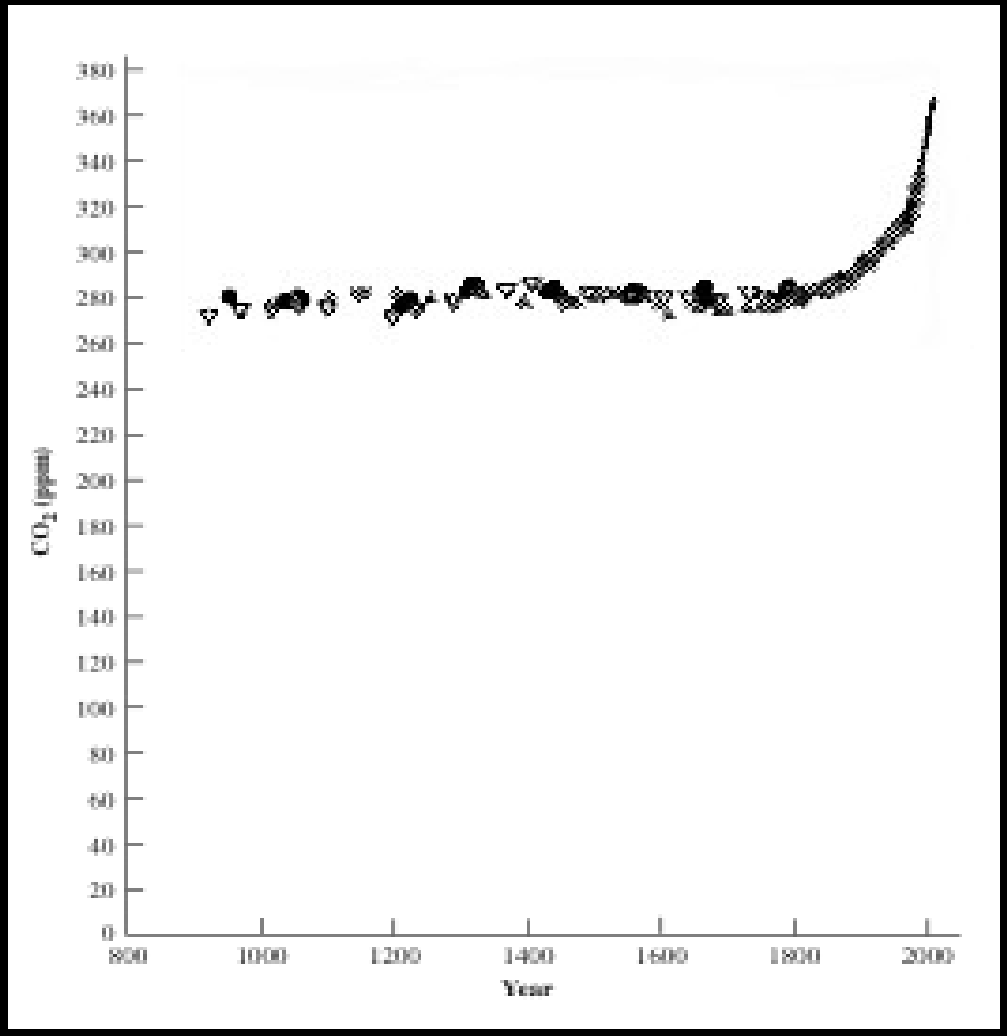
($ = US dollars; ¢ = 0.01 US dollar)

fuel	cost	per kWh (1000 Cal)	cost converted to electricity
coal	$60/ton	0.6¢	2¢
natural gas	$5/MM-cu-ft	1.5¢	5¢
gasoline	$2/gal	6¢	24¢
electricity	10¢/kWh	10¢	10¢
computer battery (laptop, Tesla)	$120/lb for 60 Wh 1000 charges	$2	$2.00
advanced Li-Ion (A123?)	$60/lb? 60Wh? 3000 charges?	$0.33?	33¢ ?
AAA battery	$1.50/battery	$1000	$1000

Plug-in Hybrid: more expensive than $15/gallon gasoline!

(but less carbon dioxide)

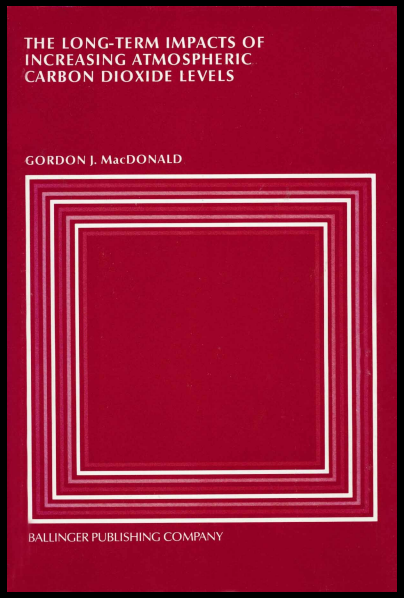
Greenhouse Gases



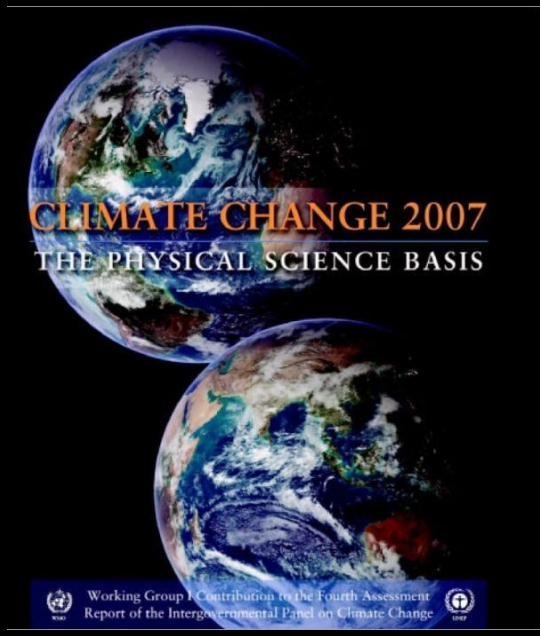
Are the fears all based on complicated computer calculations?

1896
Arhennius

1958
Revell
e

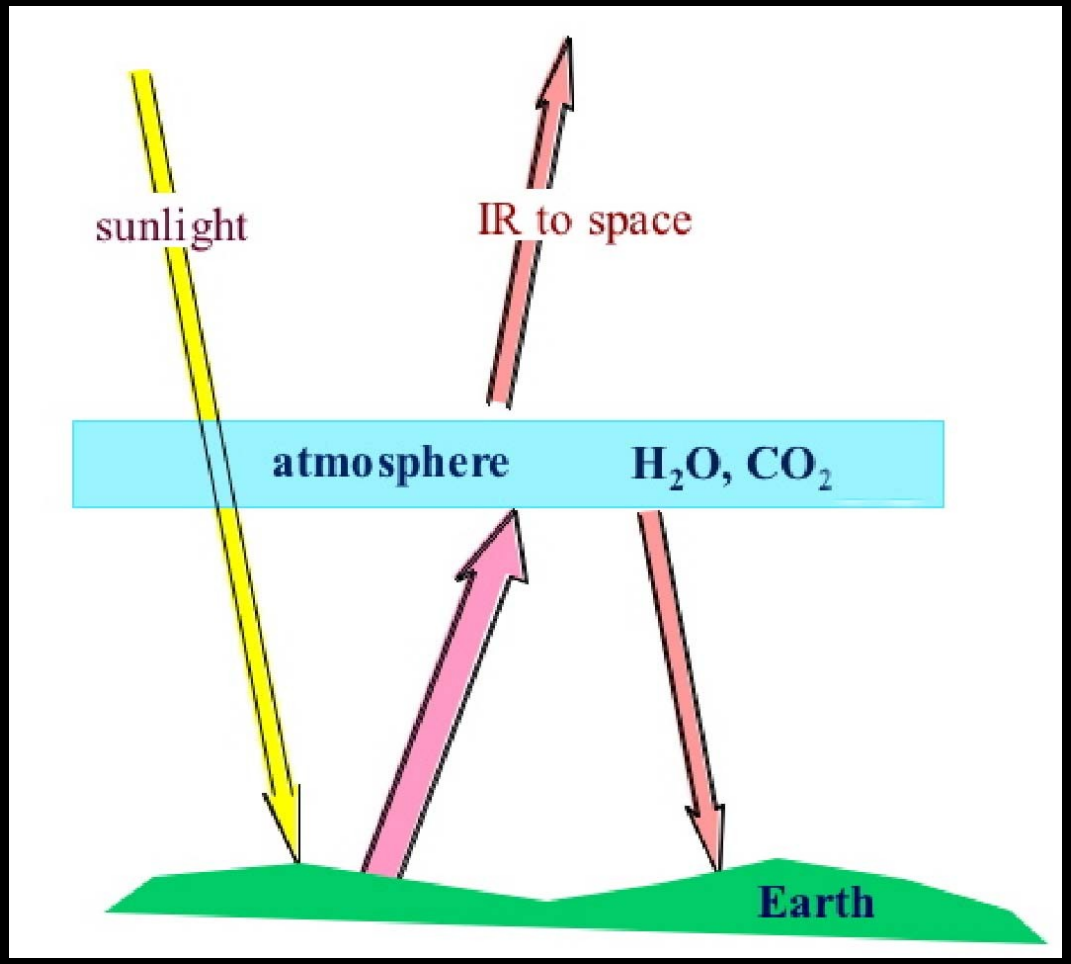


1979
MacDonal
d

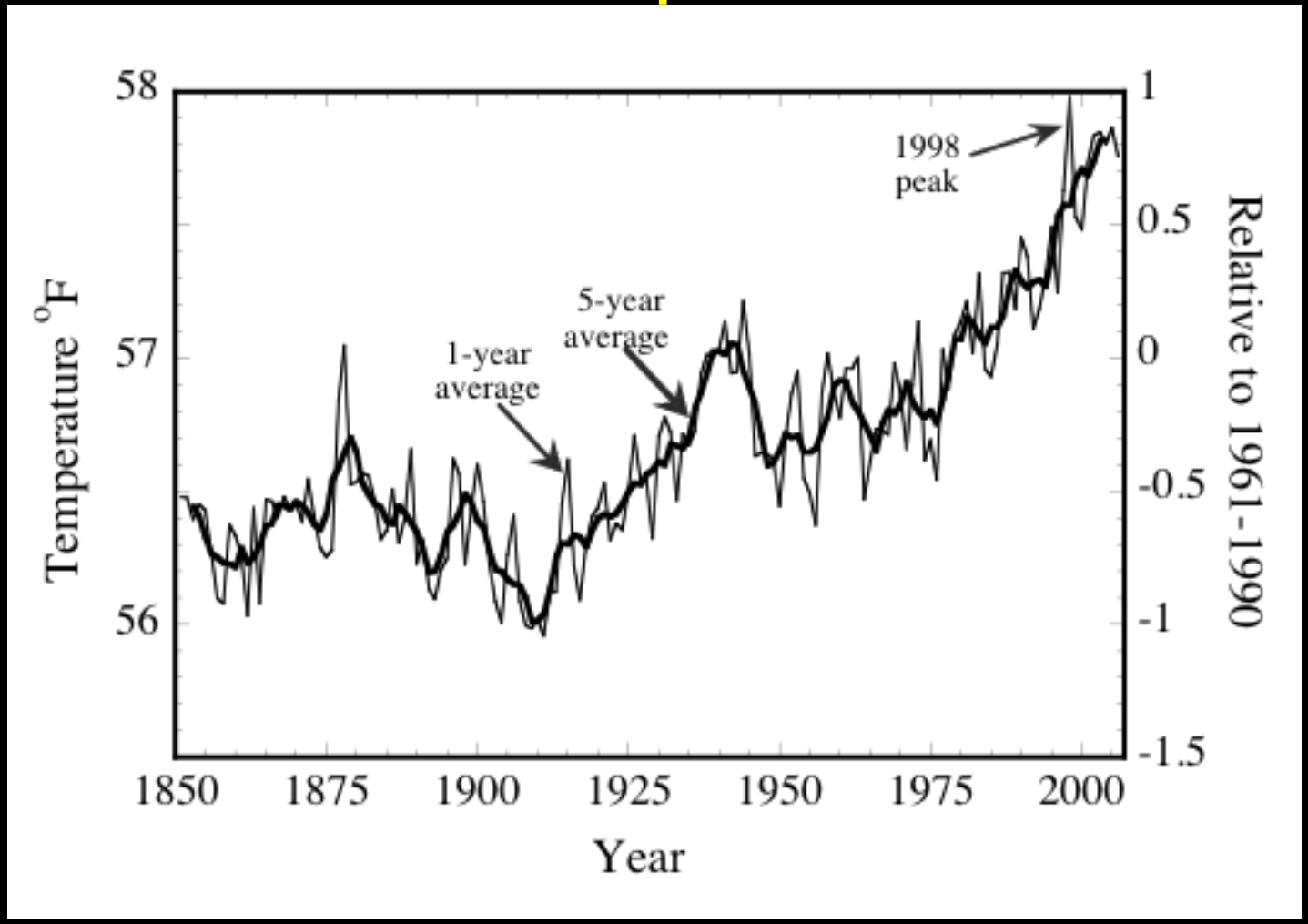


2007
IPCC

Greenhouse effect
(car in the parking lot effect)

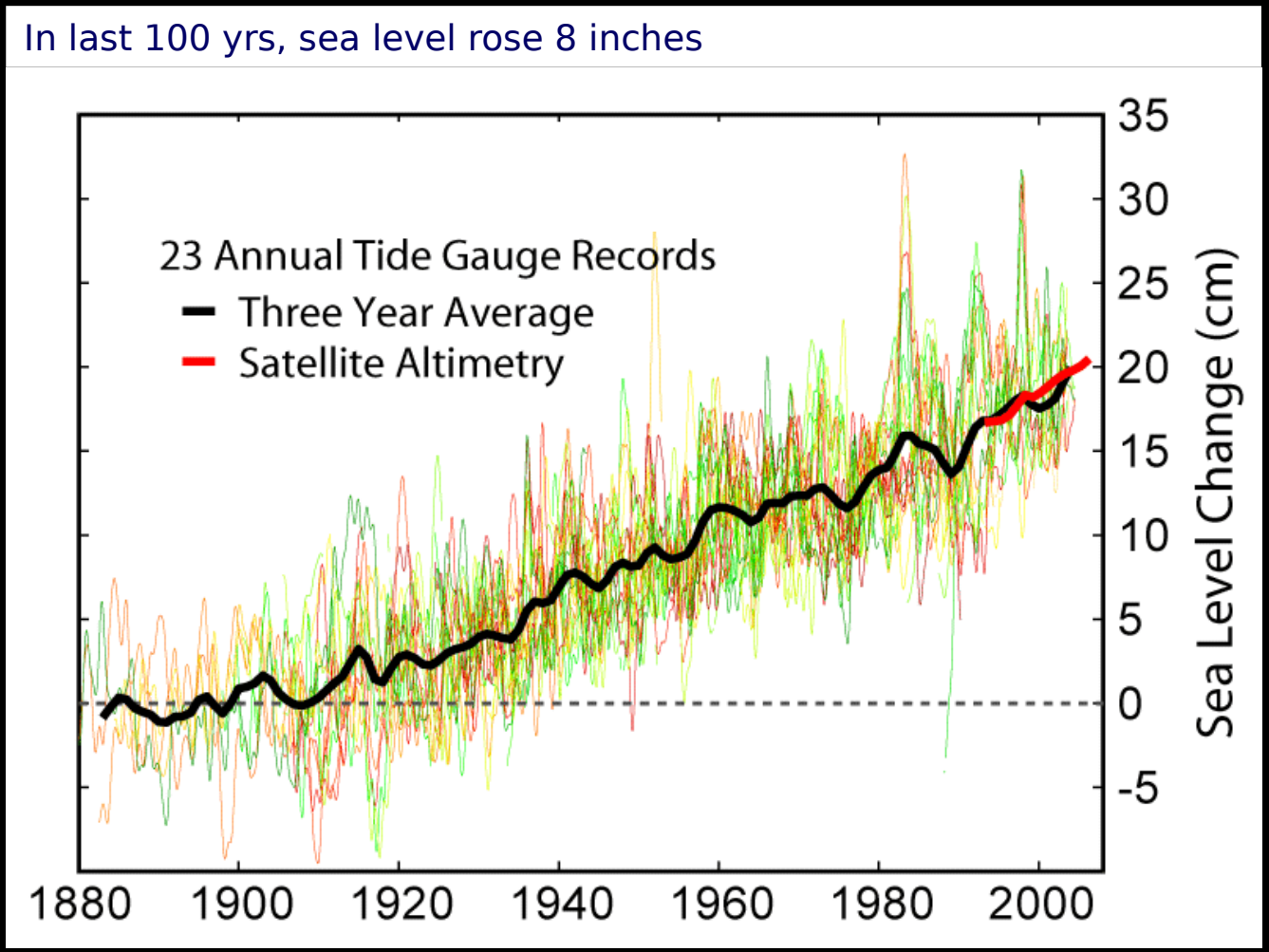


This is global



+ arctic sea ice & sea level

In last 100 yrs, sea level rose 8 inches



1979 SSMI Composite Data

2003 SSMI Composite Data

Antarctica losing ice mass

Antarctic Ice Sheet Losing Mass, According to CU-Boulder Study March 2, 2006
University of Colorado at Boulder researchers have used data from a pair of NASA satellites orbiting Earth in tandem to determine that the Antarctic ice sheet, which harbors 90 percent of Earth's ice, has lost significant mass in recent years.

The team used measurements taken with the Gravity Recovery and Climate Experiment, or GRACE, to conclude the Antarctic ice sheet is losing up to 36 cubic miles of ice, or 152 cubic kilometers, annually. By comparison, the city of Los Angeles uses about 1 cubic mile of fresh water annually. "This is the first study to indicate the total mass balance of the Antarctic ice sheet is in significant decline," said Isabella Velicogna of CU-Boulder's Cooperative Institute for Research in Environmental Sciences, chief author of the new study that appears in the March 2 online issue of Science Express.

The study was co-authored by CU-Boulder physics Professor John Wahr of CIRES, a joint campus institute of CU-Boulder and the National Oceanic and Atmospheric Administration. The estimated ice mass in Antarctica is equivalent to 0.4 millimeters of global sea rise annually, with a margin of error of 0.2 millimeters, according to the study. There are about 25 millimeters in an inch.

The most recent Intergovernmental Panel on Climate Change assessment, completed in 2001, predicted the Antarctic ice sheet would gain mass in the 21st century due to increased precipitation in a warming climate. But the new study signals a reduction in the continent's total ice mass, with the bulk of loss occurring in the West Antarctic ice sheet, said Velicogna.

Researchers used GRACE data to calculate the total ice mass in Antarctica between April 2002 and August 2005 for the study, said Velicogna, who also is affiliated with the Jet Propulsion Laboratory in Pasadena.

SciencExpress 2 March 2006 p 1 /
10.1126/science.1123785

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SciencExpress 2 March 2006 p 1 / 10.1126/science.1123785


Positive proof of global warming.
18th Century
1900
1950
1970
1980
1990
2006

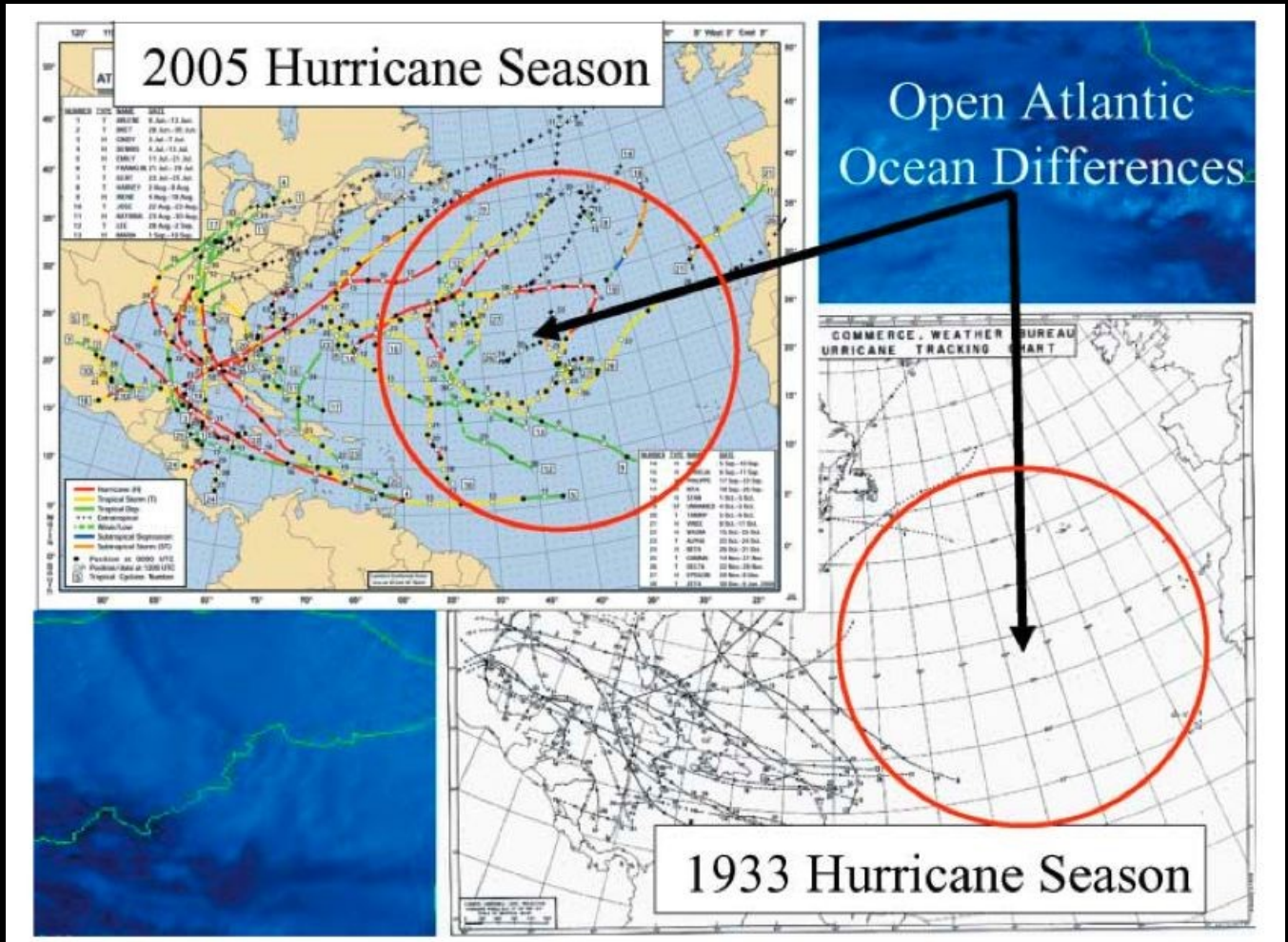
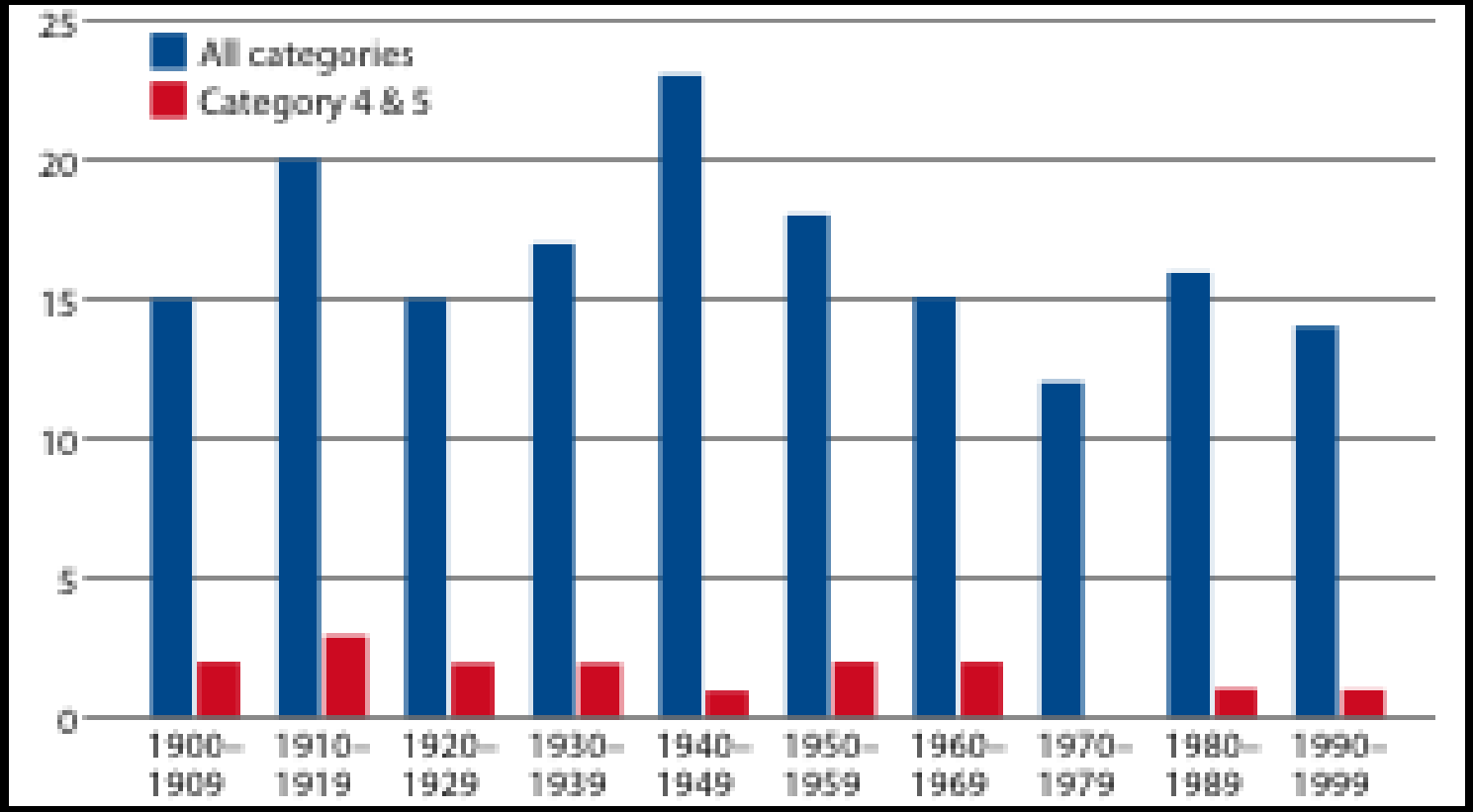
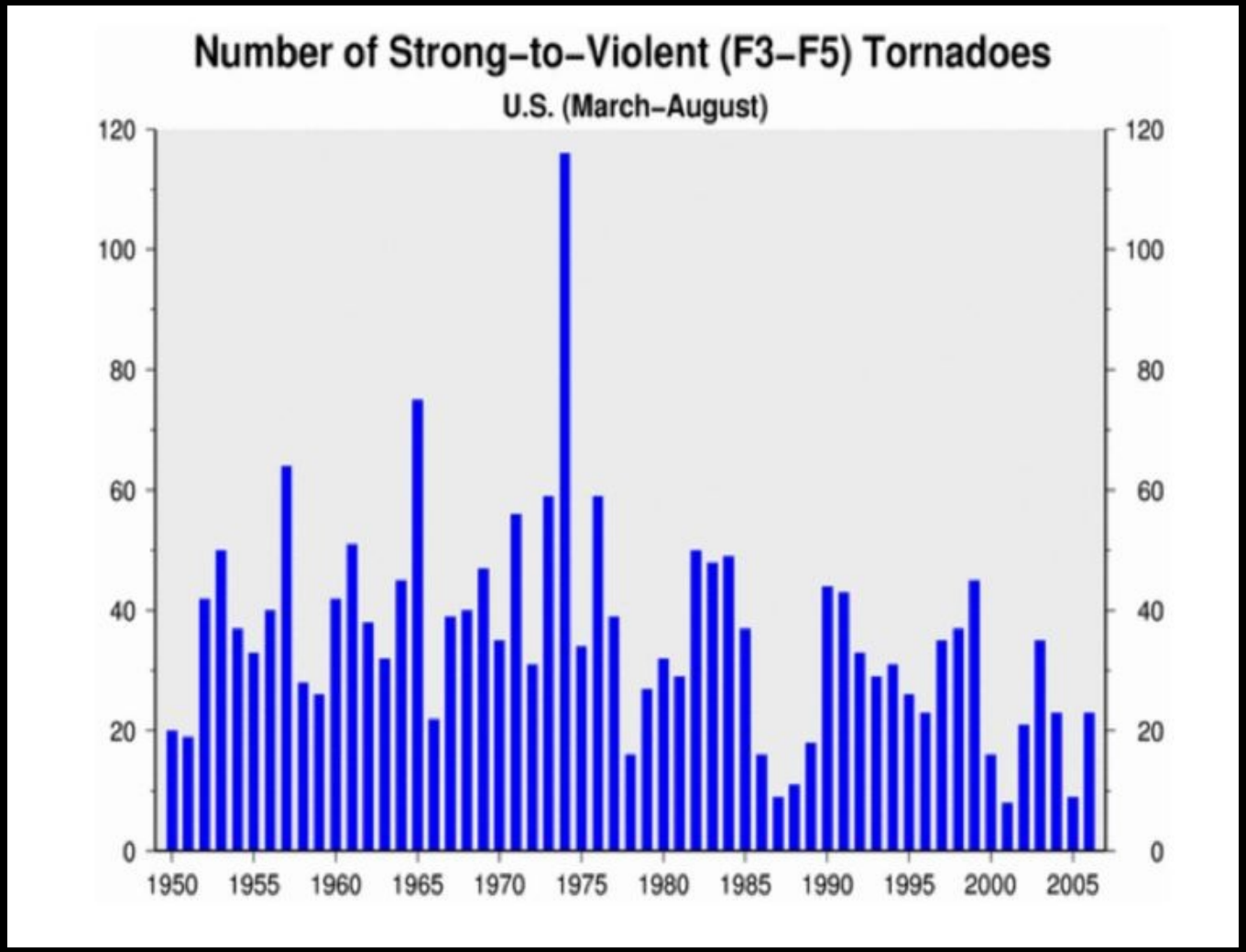


Fig. 1. Track maps of the Atlantic hurricane seasons of 2005 and 1933, the two busiest hurricane years on record for tropical cyclone frequency. The circles highlight large differences in activity that occurred over the open Atlantic Ocean.

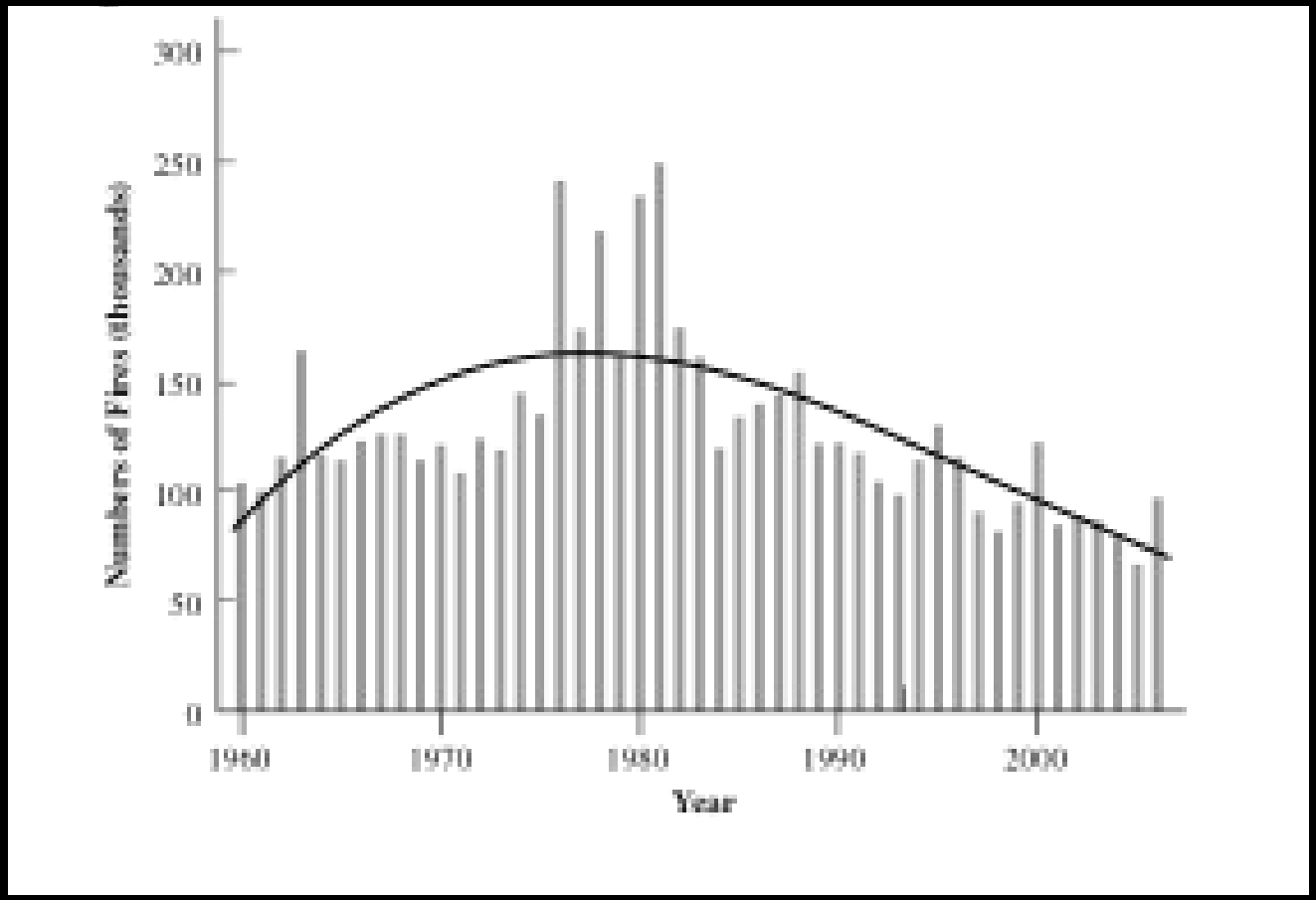
Hurricanes that hit the US

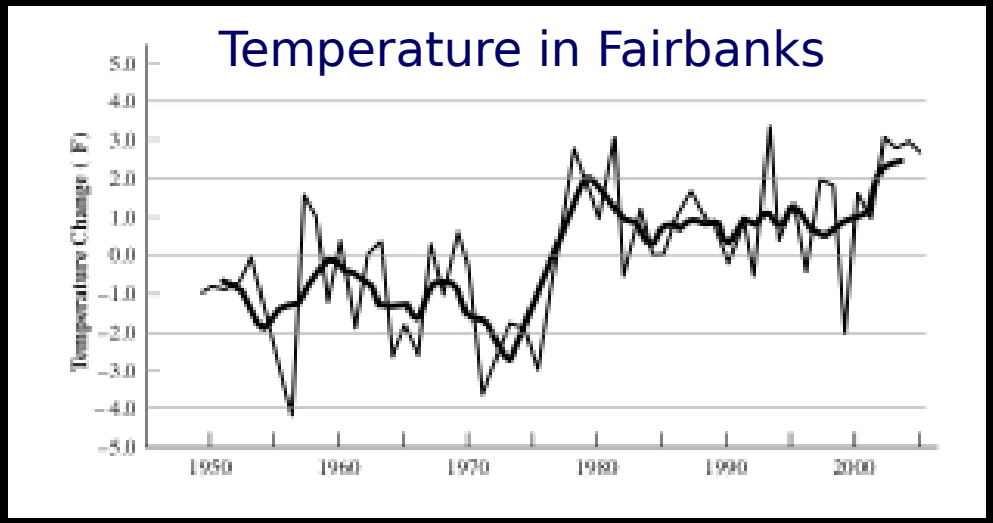


definitely NOT increasing!

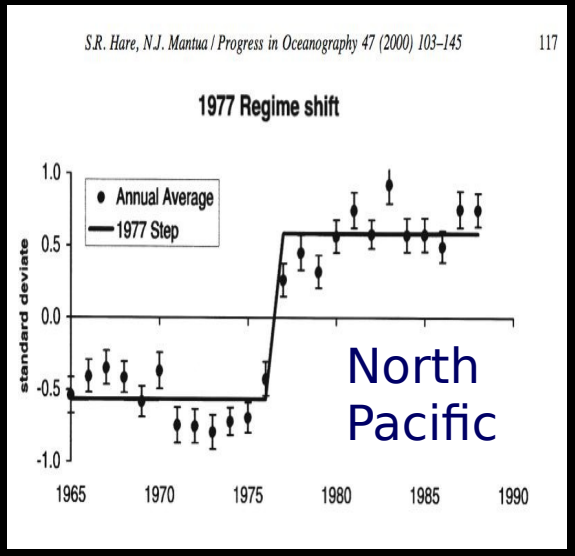

Number of Strong–to–Violent (F3–F5) Tornadoes
U.S. (March–August)
120
100
80
60
40
20
0
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005

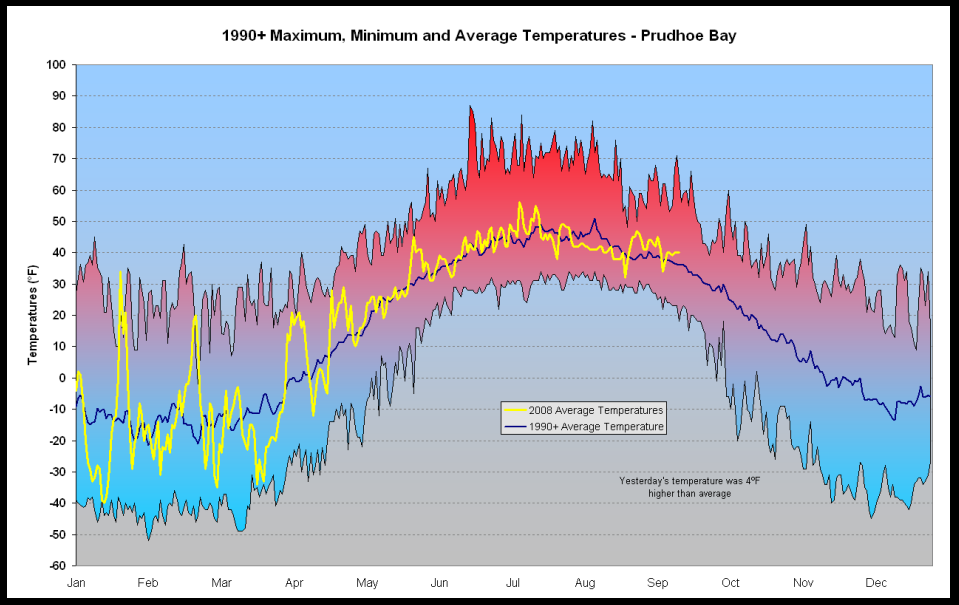
Wildfires (in US)

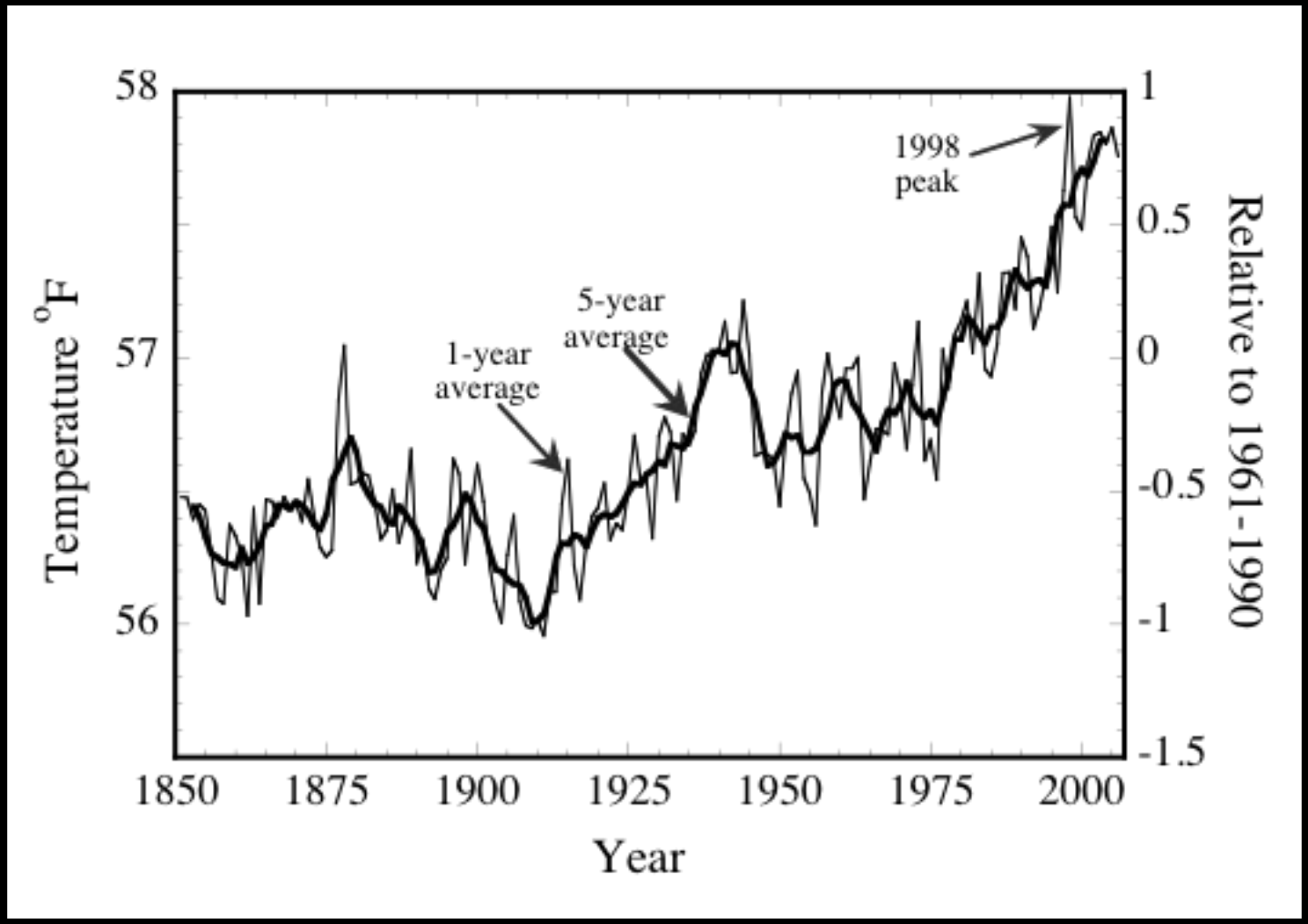




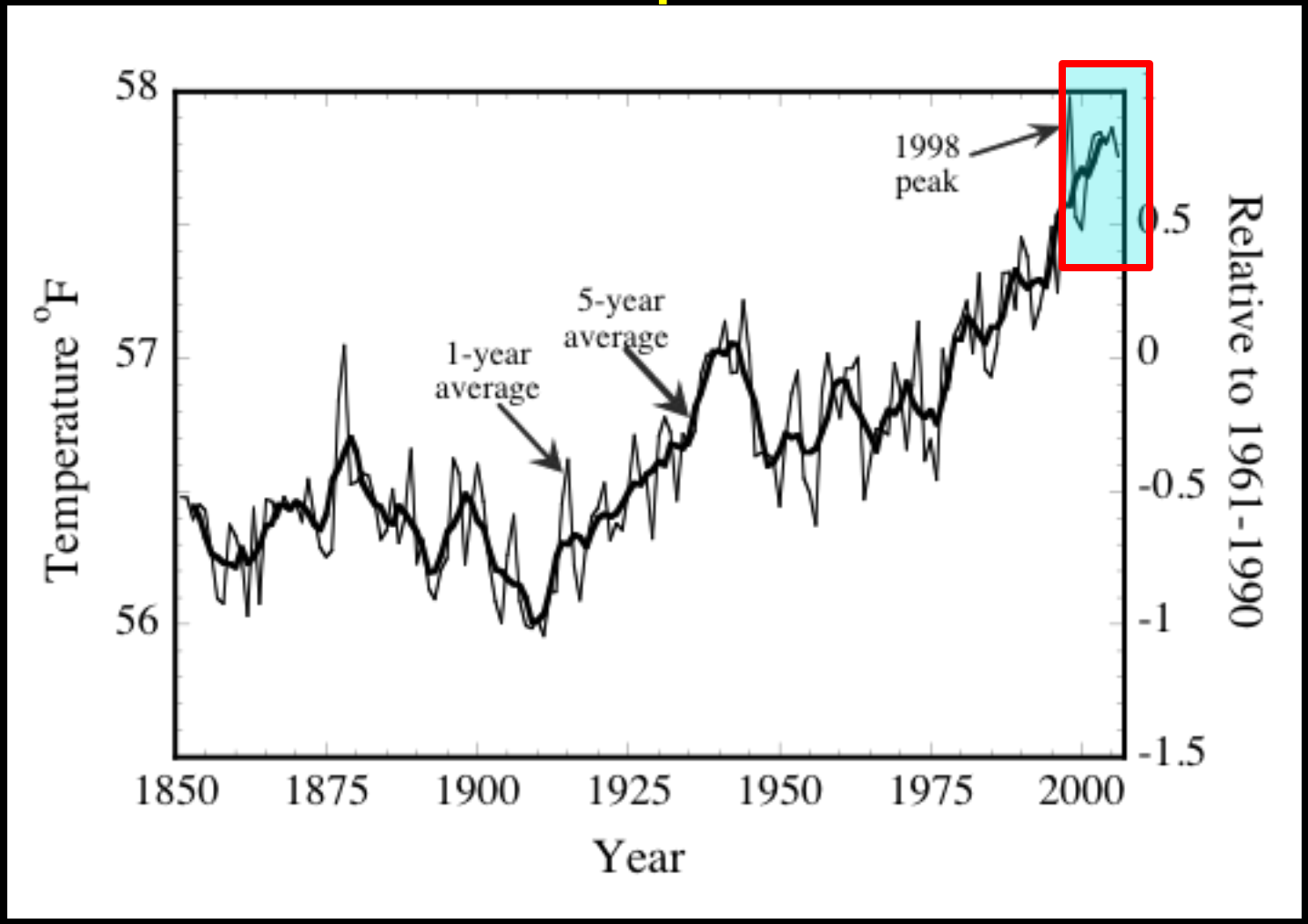
Alaska is Melting?



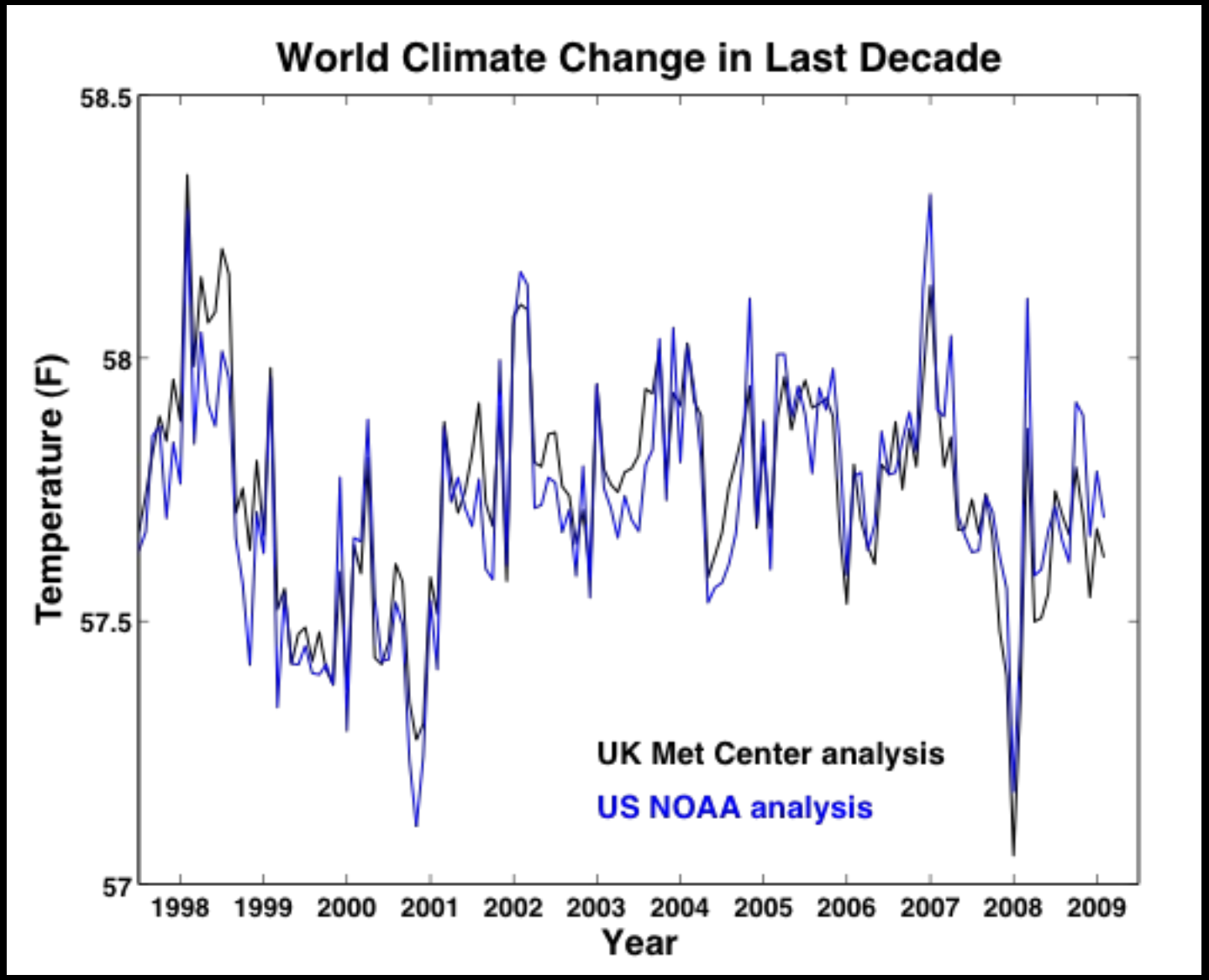



58
57
56
Temperature °F
1
0.5
0
-0.5
-1
-1.5
Relative to 1961-1990
1998
peak
5-year
average
1-year
average
1850
1875
1900
1925
1950
1975
2000
Year

This is global

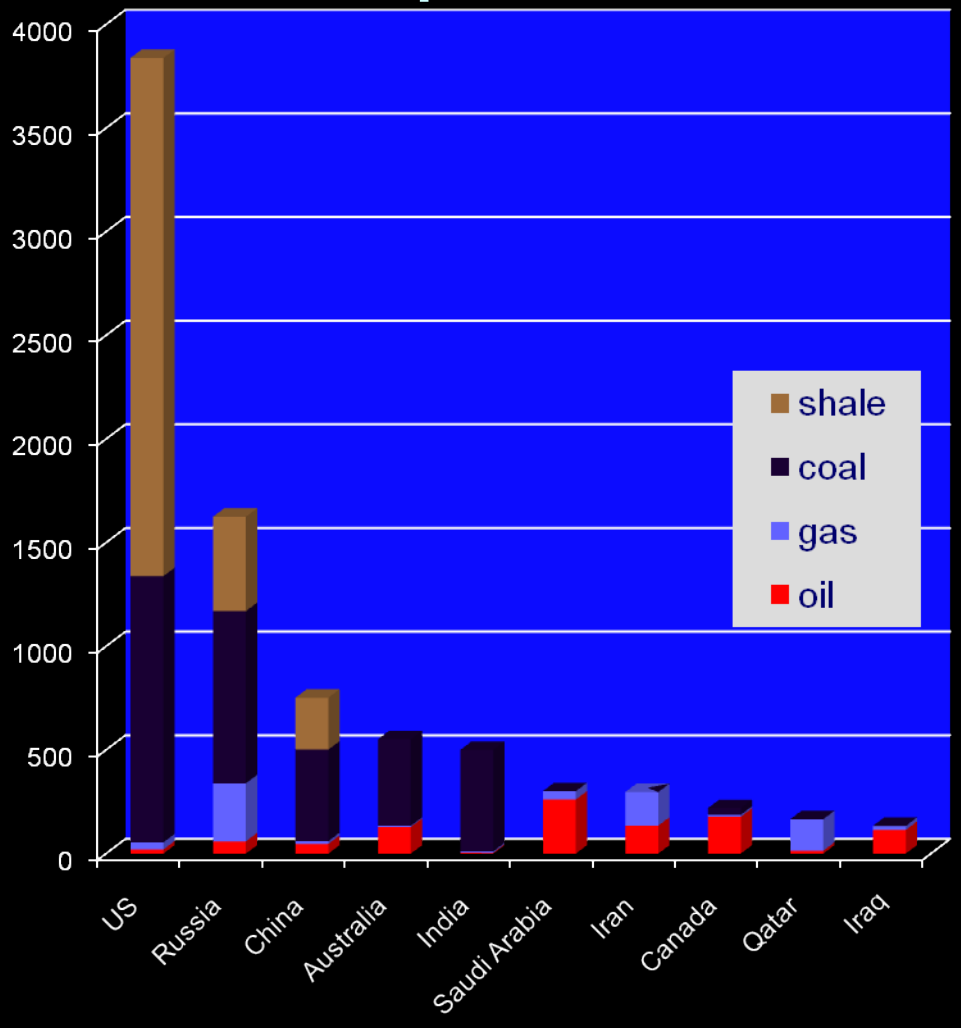


+ arctic sea ice & sea level

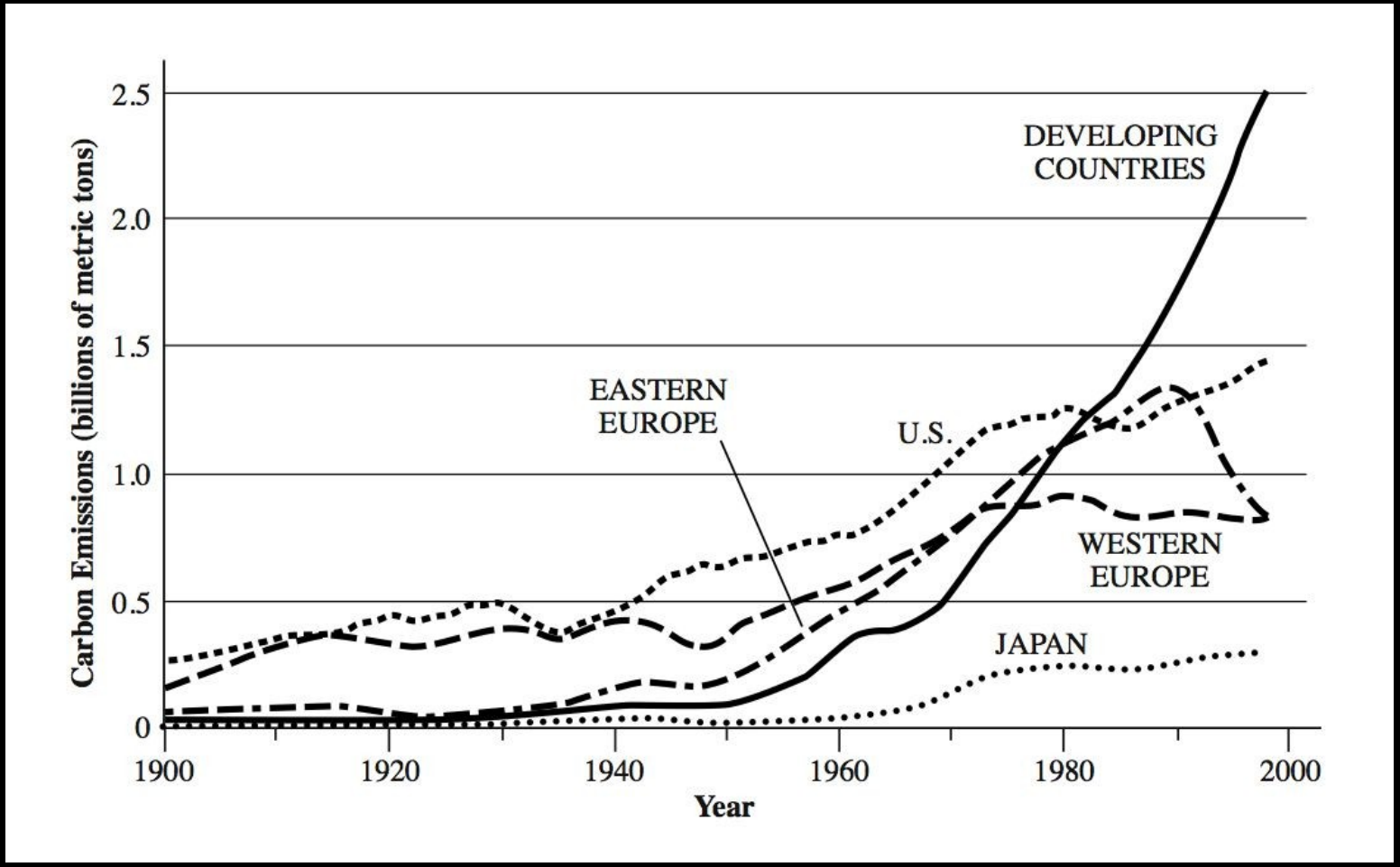

World Climate Change in Last Decade
58.5
58
57.5
57
Temperature (F)
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year
UK Met Center analysis
US NOAA analysis

How rapidly are we running out of fossil fuels?

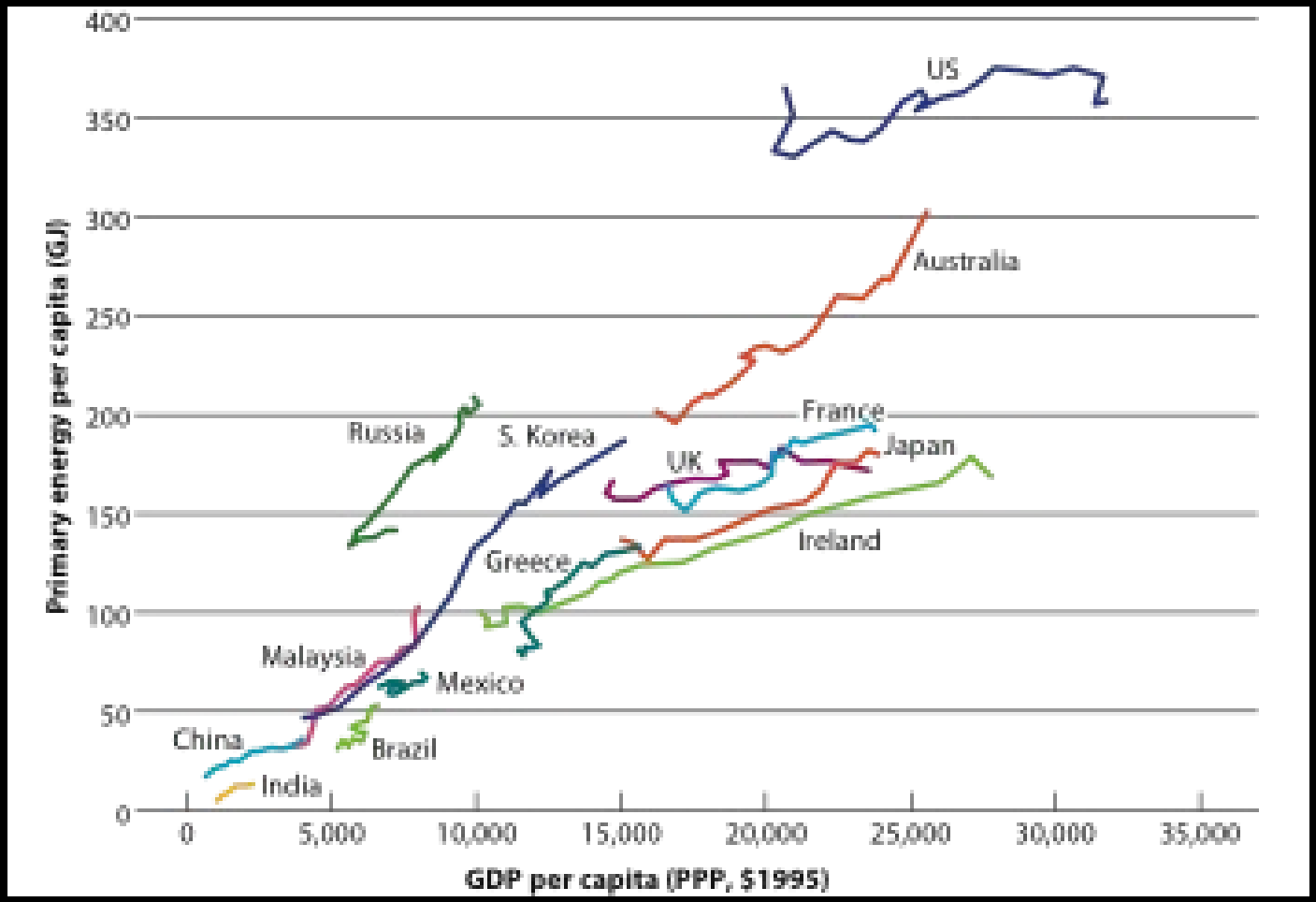
billion barrel of oil equivalent



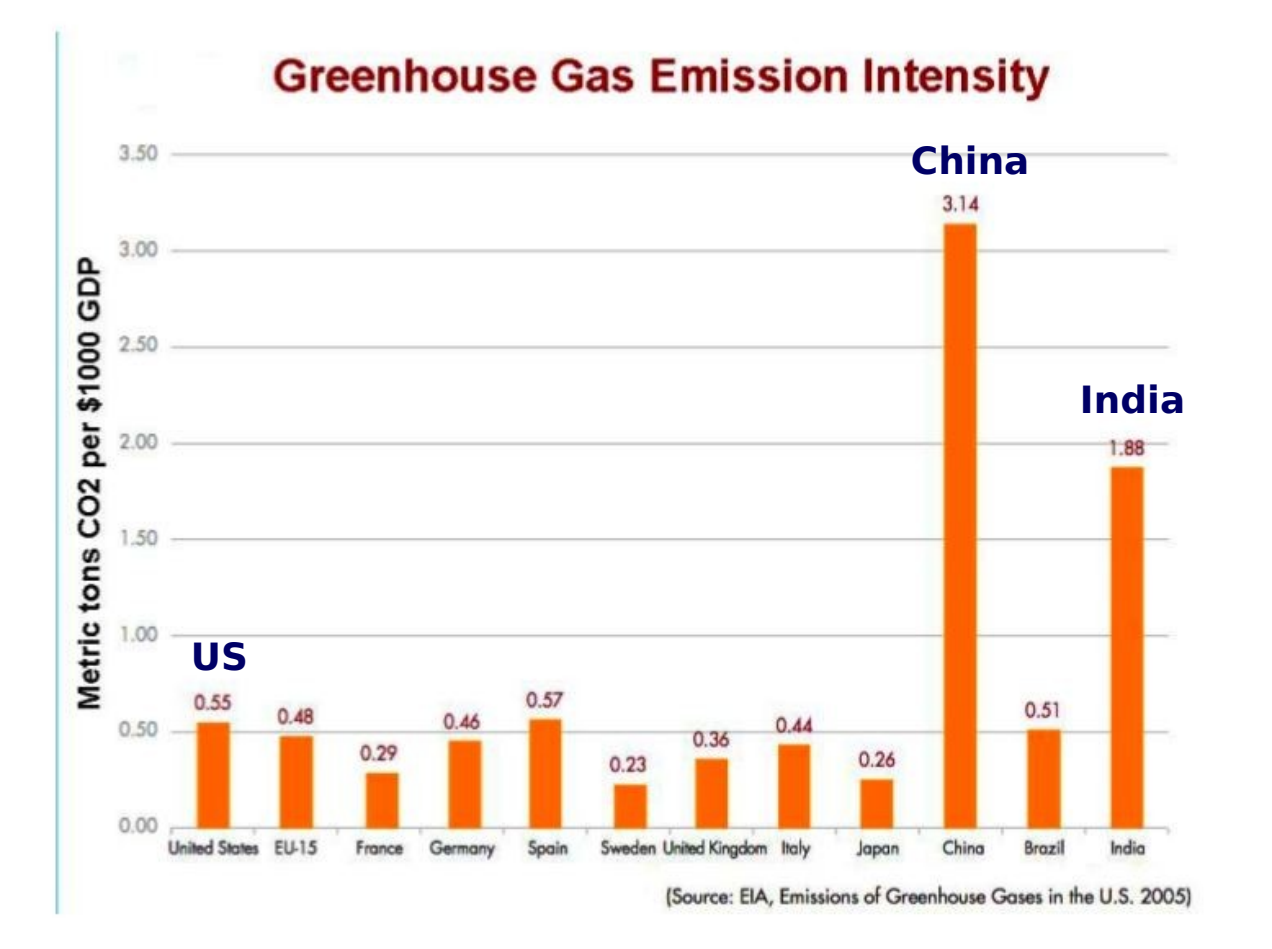
Carbon Dioxide



Energy and Wealth

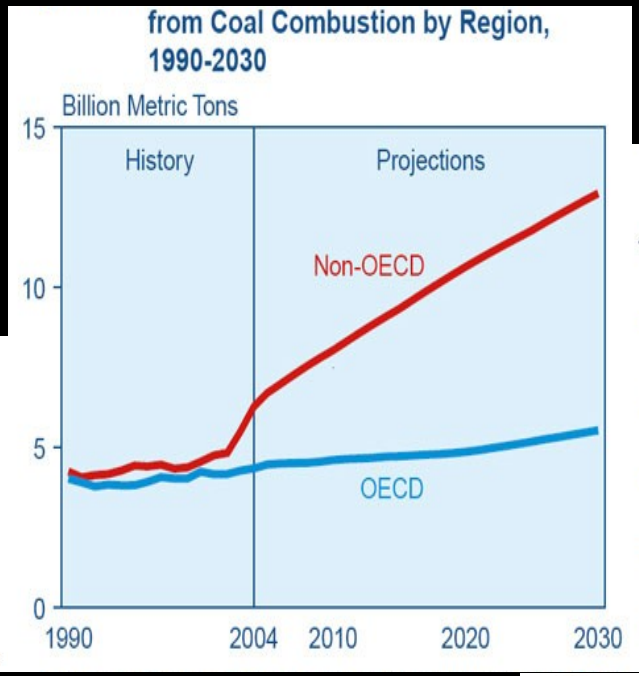


Pollution per GDP

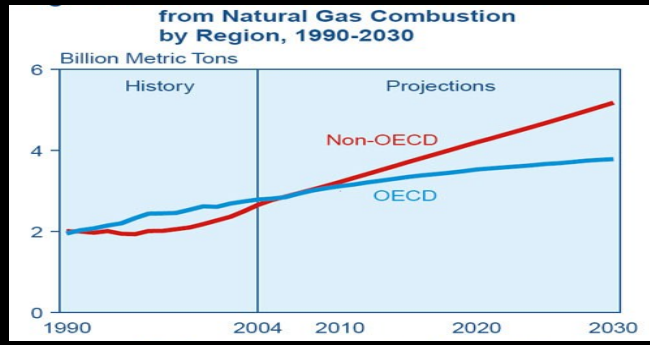


World Carbon Dioxide Projections

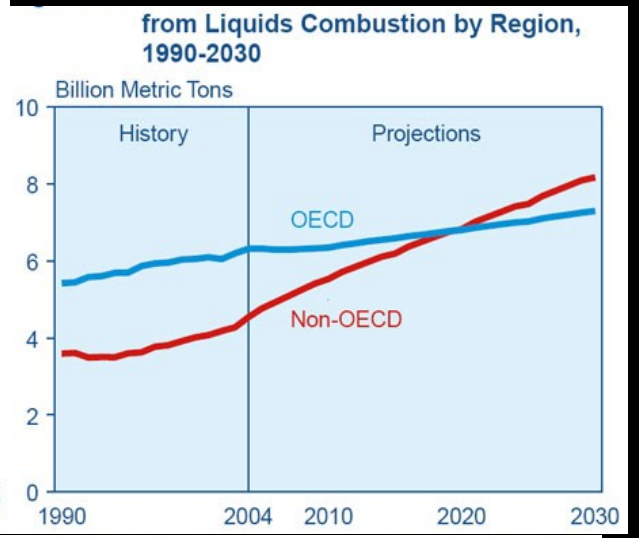
Coal



Natural Gas

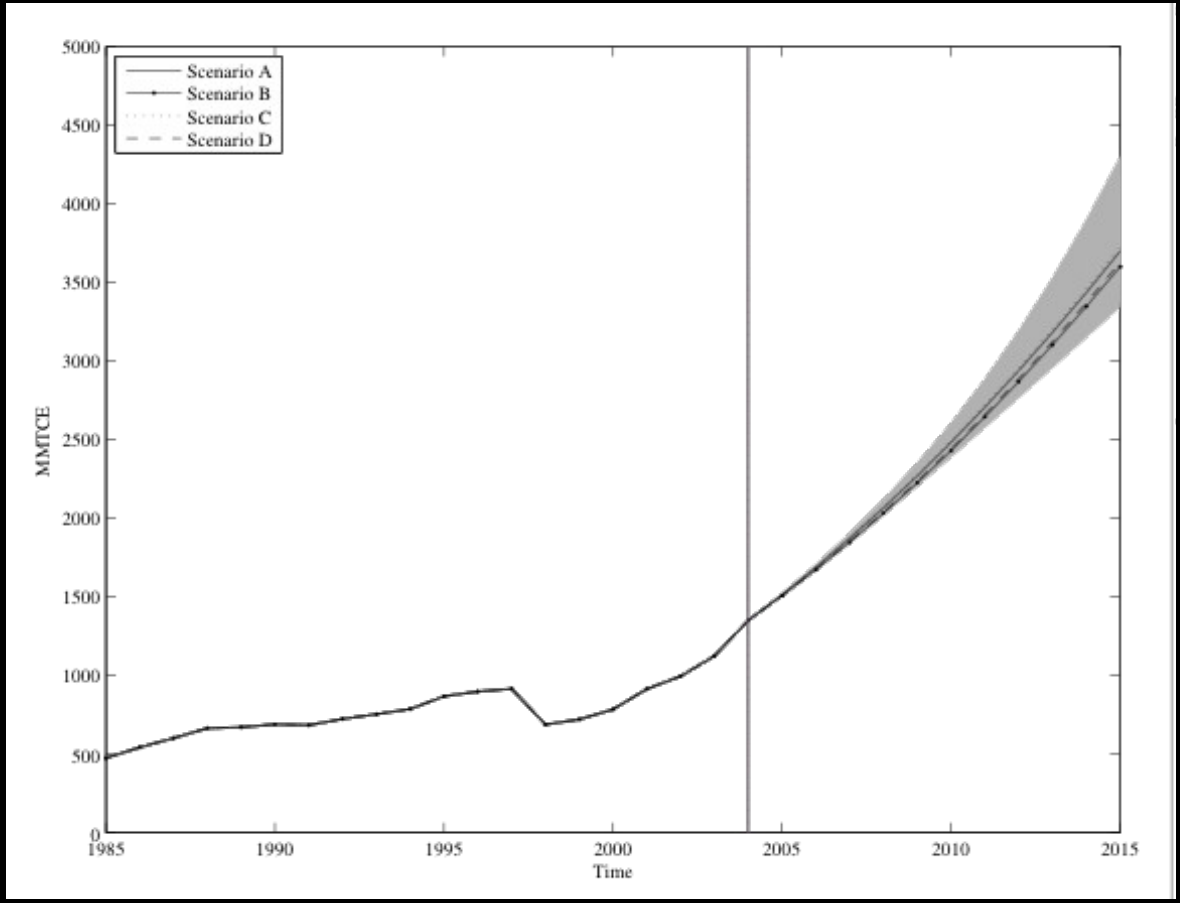


Oil



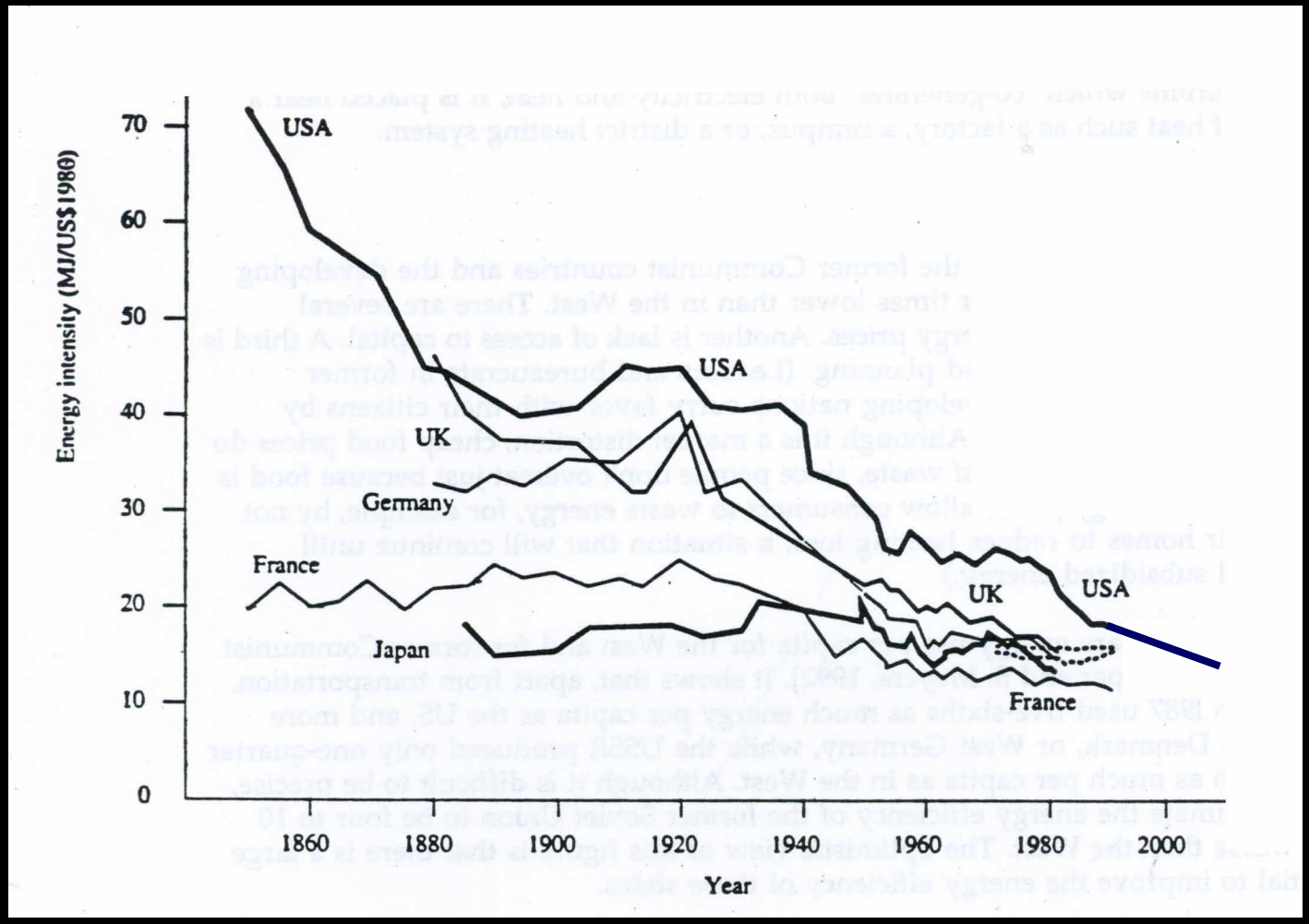
Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

China's CO_2



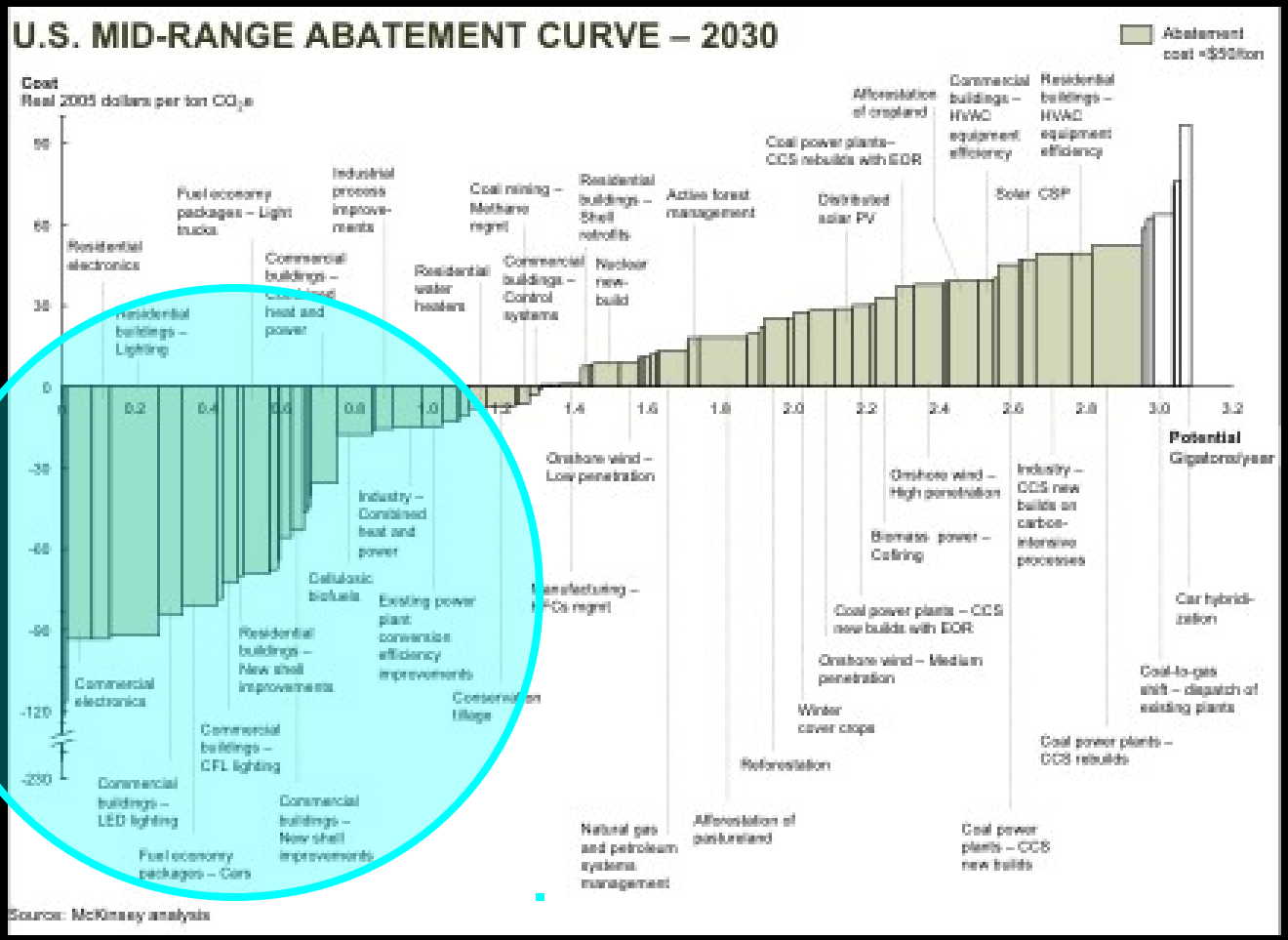
Forecasting the Path of China's CO2 Emissions Using Province Level Information
by Maximilian Auffhammer & Richard T. Carson (2009)

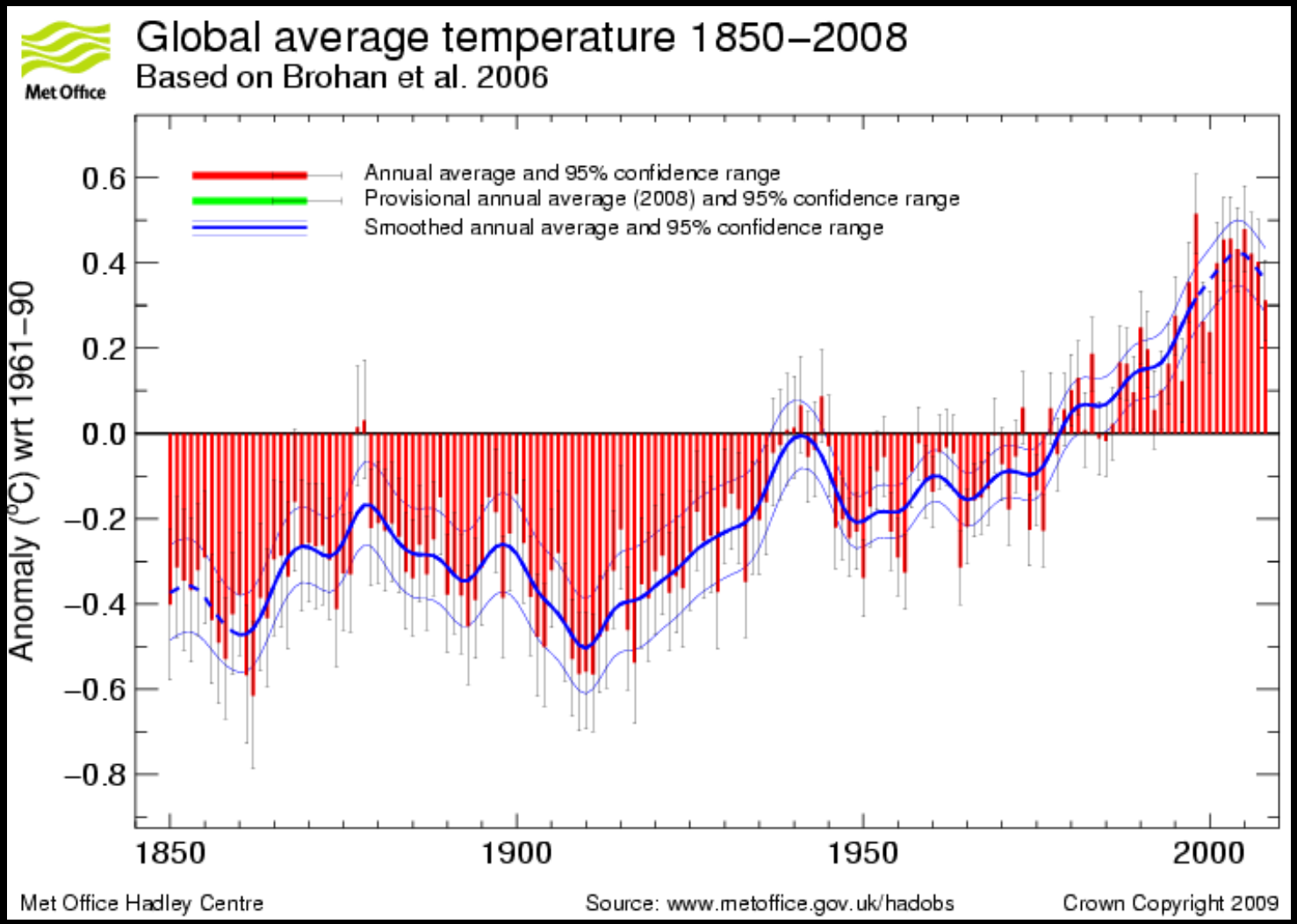
Energy per GDP



source: L. Shipper & S. Meyers

McKinsey Analysis




Met Office
Global average temperature 1850–2008
Based on Brohan et al. 2006
Annual average and 95% confidence range
Provisional annual average (2008) and 95% confidence range
Smoothed annual average and 95% confidence range
Anomaly (°C) wrt 1961–90
0.6
0.4
0.2
0.0
–0.2
–0.4
–0.6
–0.8
1850
1900
1950
2000
Met Office Hadley Centre
Source: www.metoffice.gov.uk/hadobs
Crown Copyright 2009

Cloud cover: the big unknown

2% change in cloud cover would overwhelm human CO_2

Richard A Muller
UC Berkeley

compact fluorescents in Notre Dame de Paris

What do we do?

C^7 NSW

Comfortable Conservation

Clean Coal

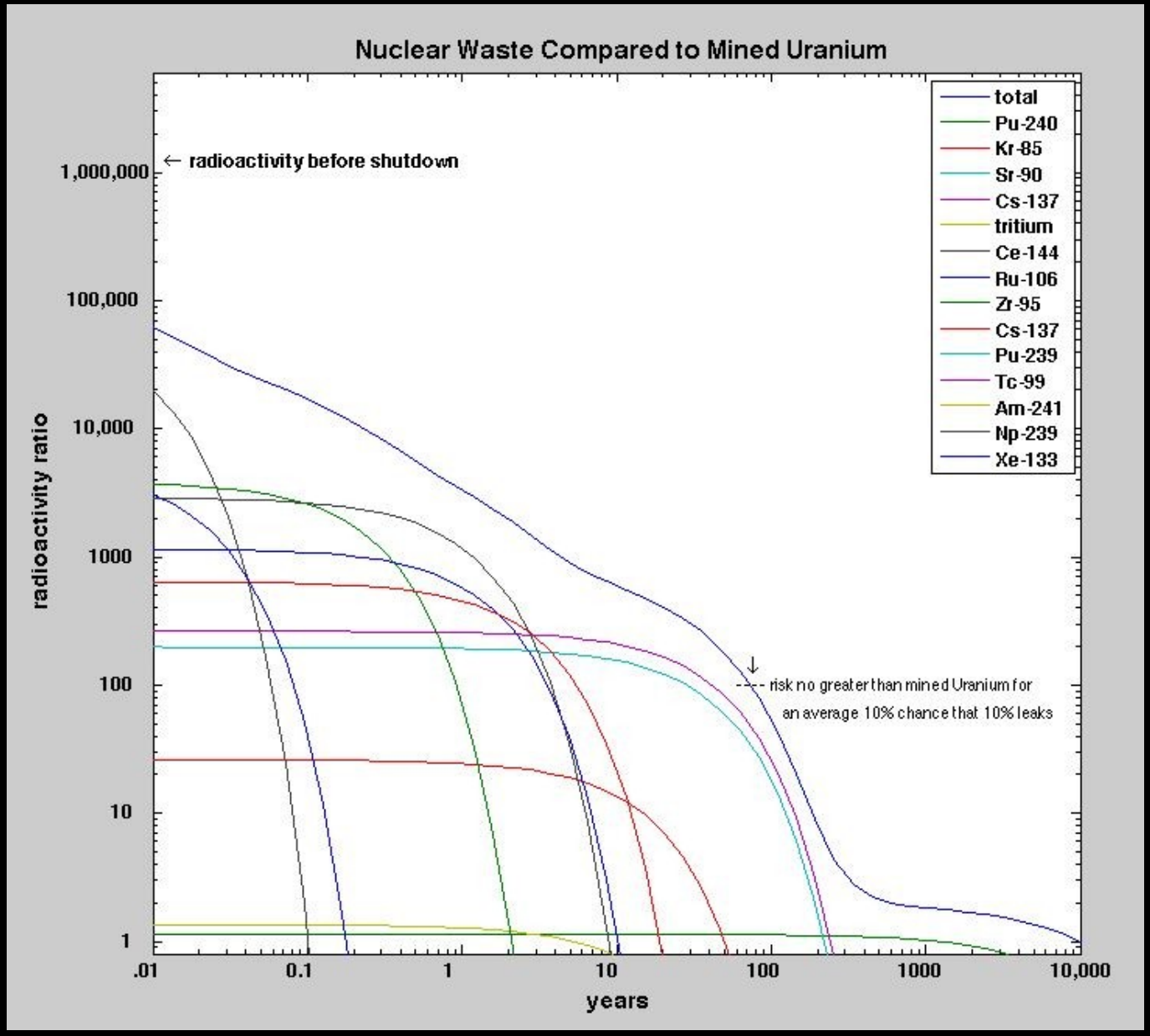
Chinese Carbon Credits

Nukes, Solar, Wind

Wind turbines

Solar Cells

Nuclear Waste

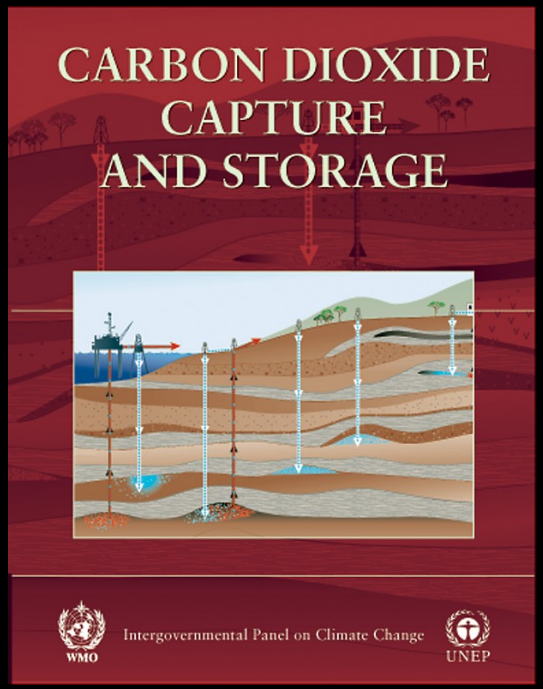


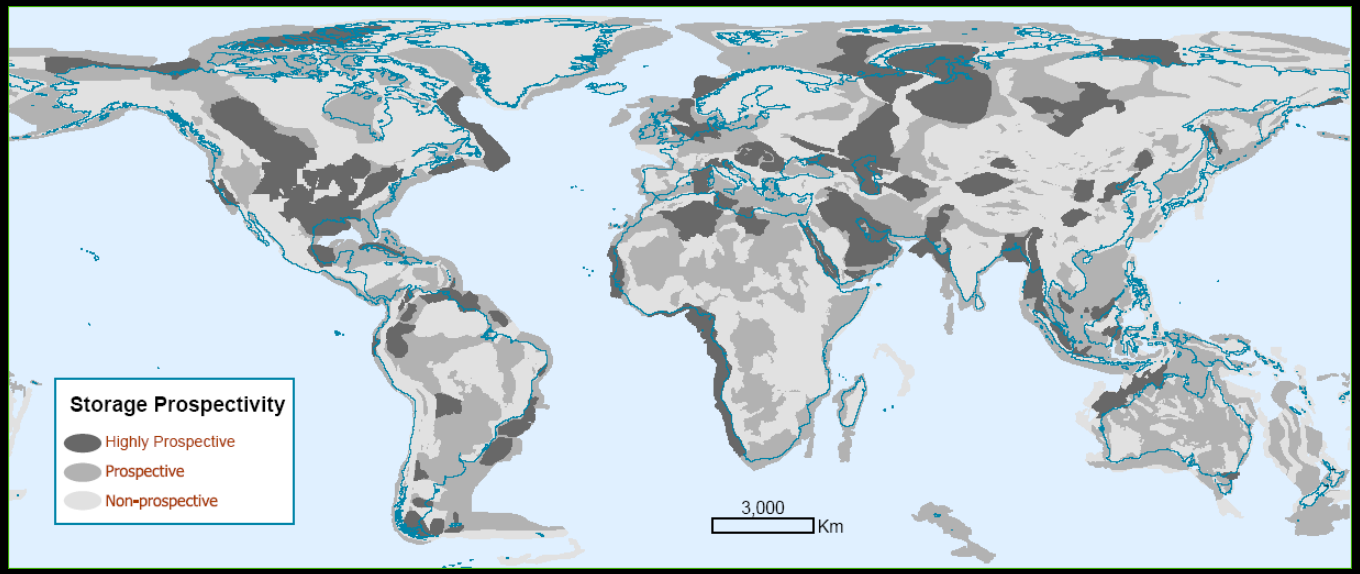
Truly Clean Coal?

Sequestration of the carbon dioxide (CSS)

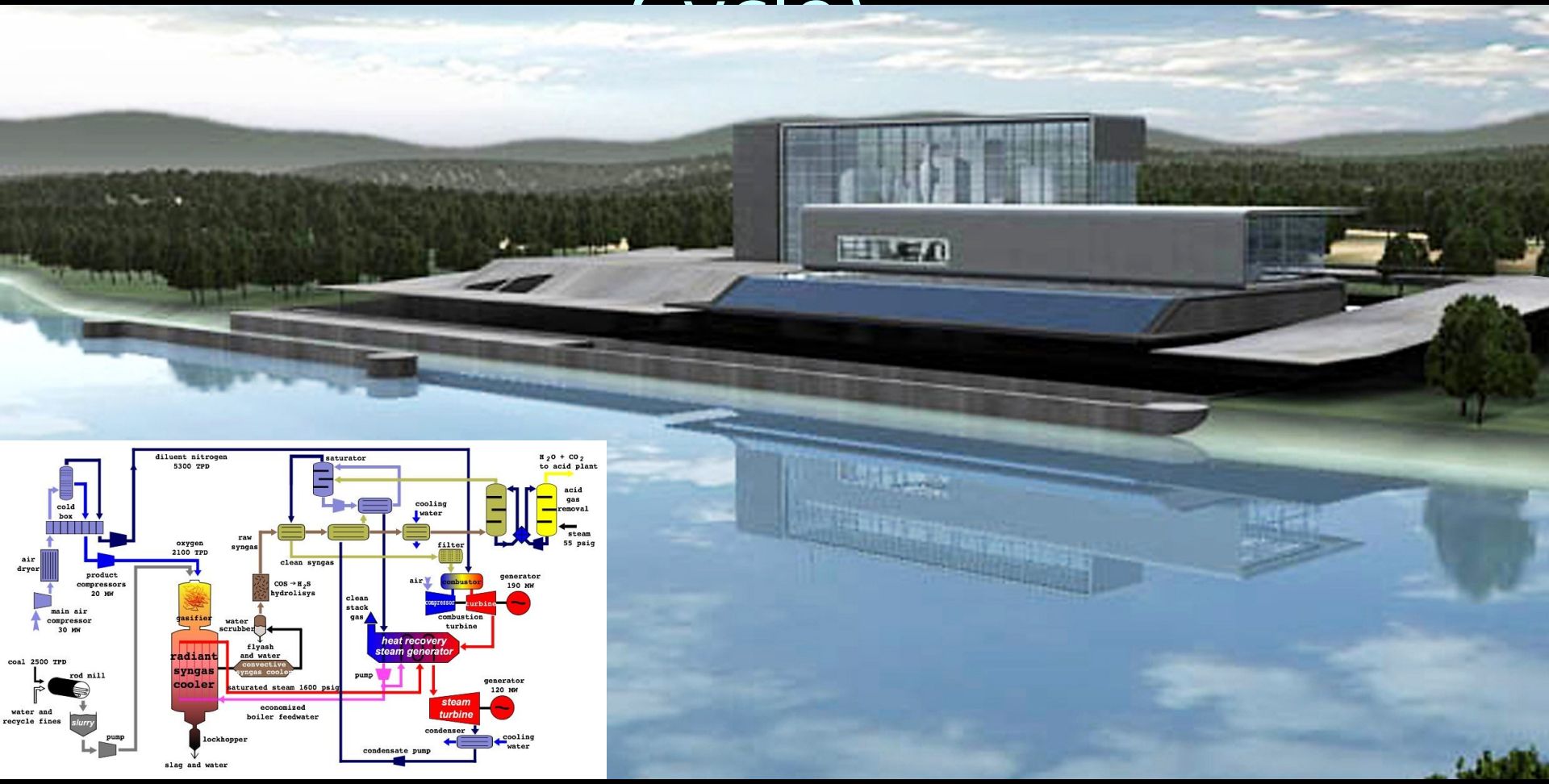
Cost: 4¢ per kWh

We can't just suck it out of the air.

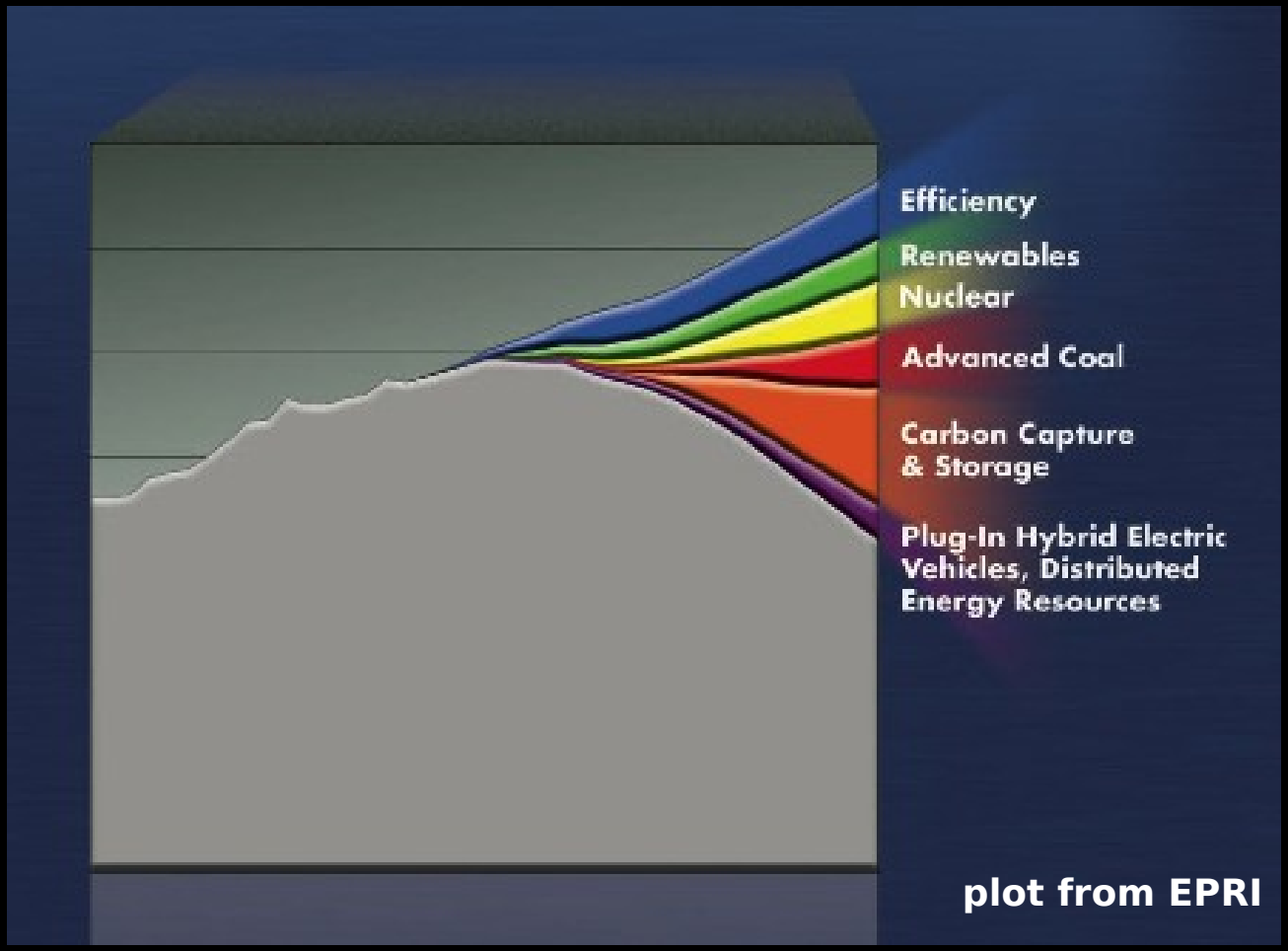




Efficient and Clean Coal: IGCC (Integrated Gas Combined Cycle)



What can we do?



Future Energy Tech

- IGCC (clean coal)
- LiIon
- Thin film solar: CdTe, CIGS, a-Si
- Ga multijunction solar
- Pebble Bed Nukes
- Waste Storage
- Coal bed gasification
- non-corn biofuels
- CTL (Coal-To-Liquid; Fisher-Tropsch)
- Coal-bed methane
- Enhanced Oil Recovery
- Solar concentrator
- Indium shortages
- DC power transmission
- Inverters
- coal bed gasification

OMITTED (on purpose):

plug-in hybrids, hydrogen economy, fuel cells, fusion, breeder reactors

Global warming will come from the developing world. Unfortunately.

Not good enough to set an example …

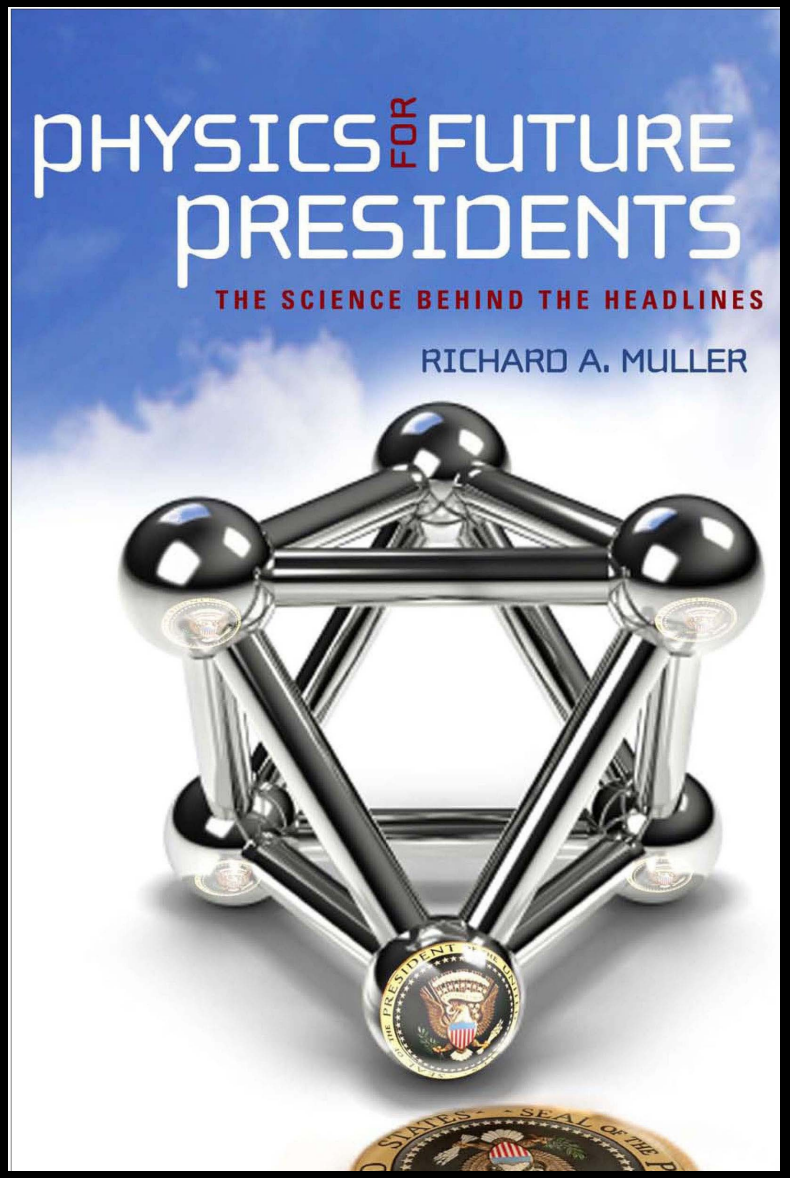
if developing countries can't afford to follow that example.

Must stop Green Bickering and

Cleaner than Thou Pontificating

We need it all: conservation, solar, wind, clean coal, nukes, coal to liquid …

www.Muller.LBL.Gov

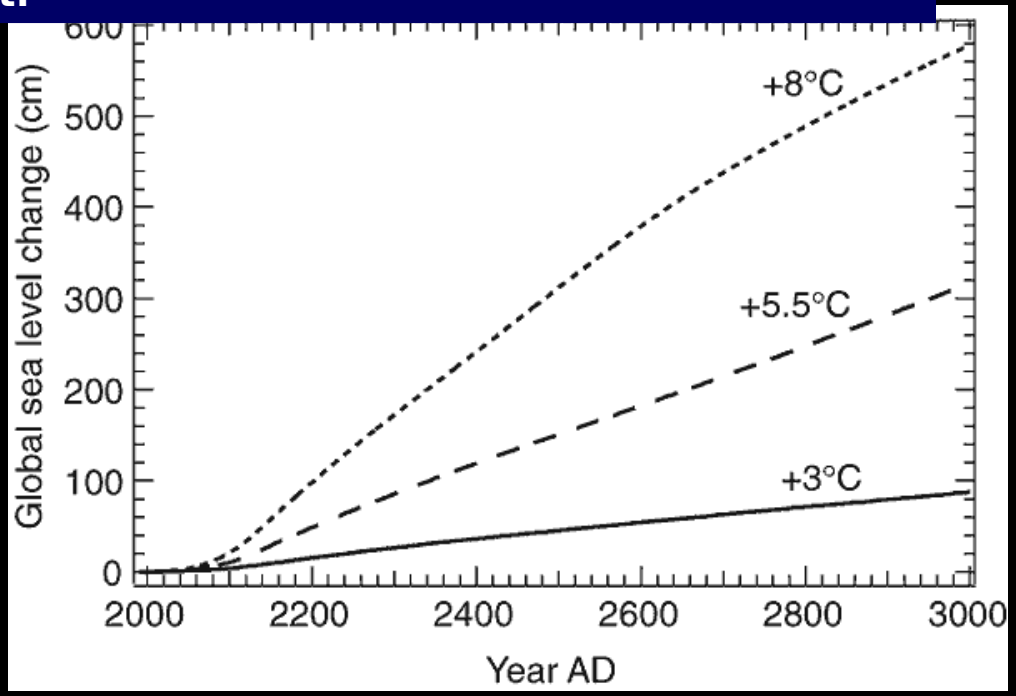


Greenland melting?

Al Gore – *An Inconvenient Truth*: "Tony Blair's scientific advisor has said that because of what is happening in Greenland right now, the maps of the World will have to be redrawn." -- but not, of course, for a few hundred years.

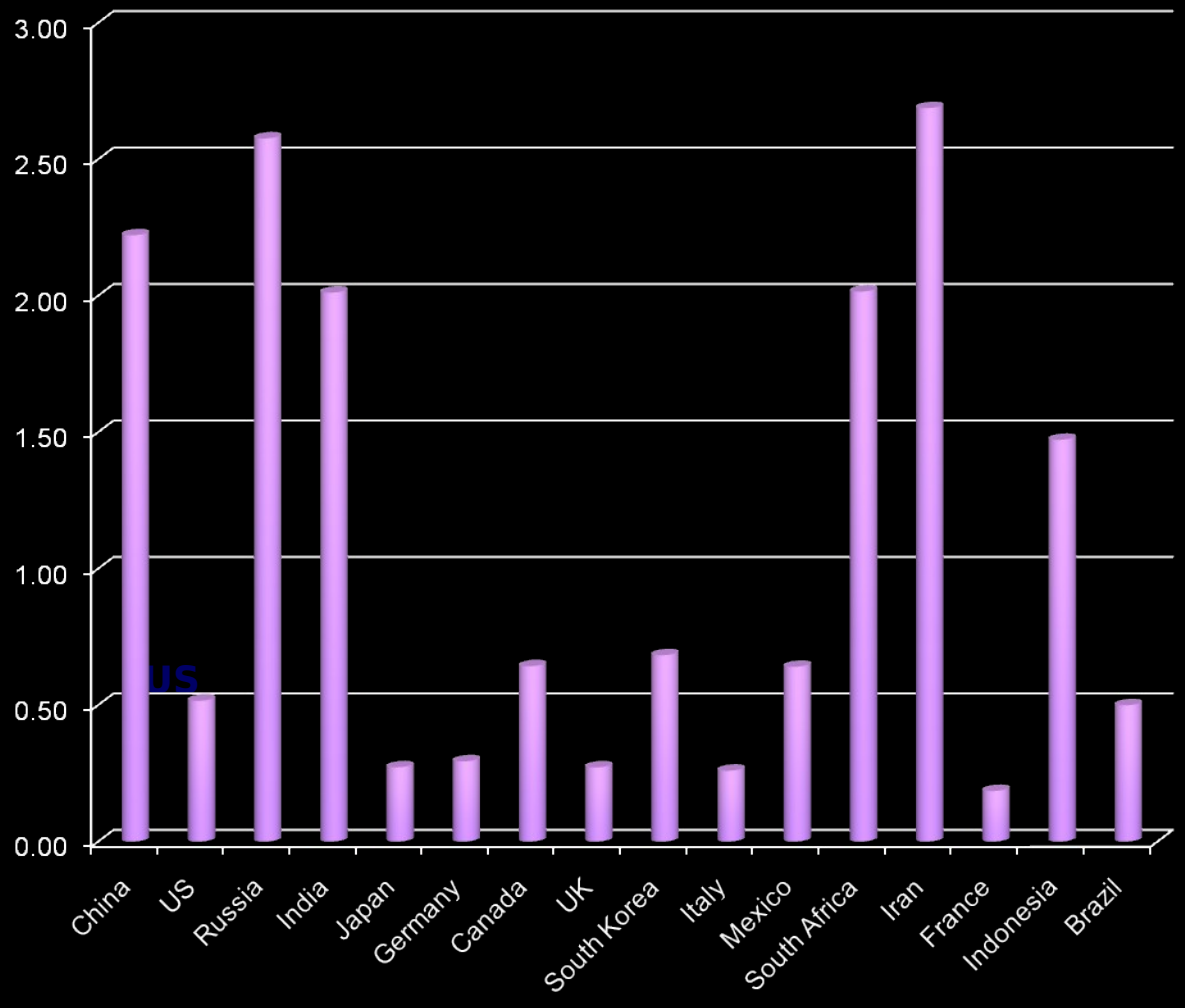
"If Greenland melted or broke up and slipped into the sea -- or if half of Greenland and half of Antarctica melted or broke up and slipped into the sea, sea levels worldwide would increase by between 18 and 20 feet."

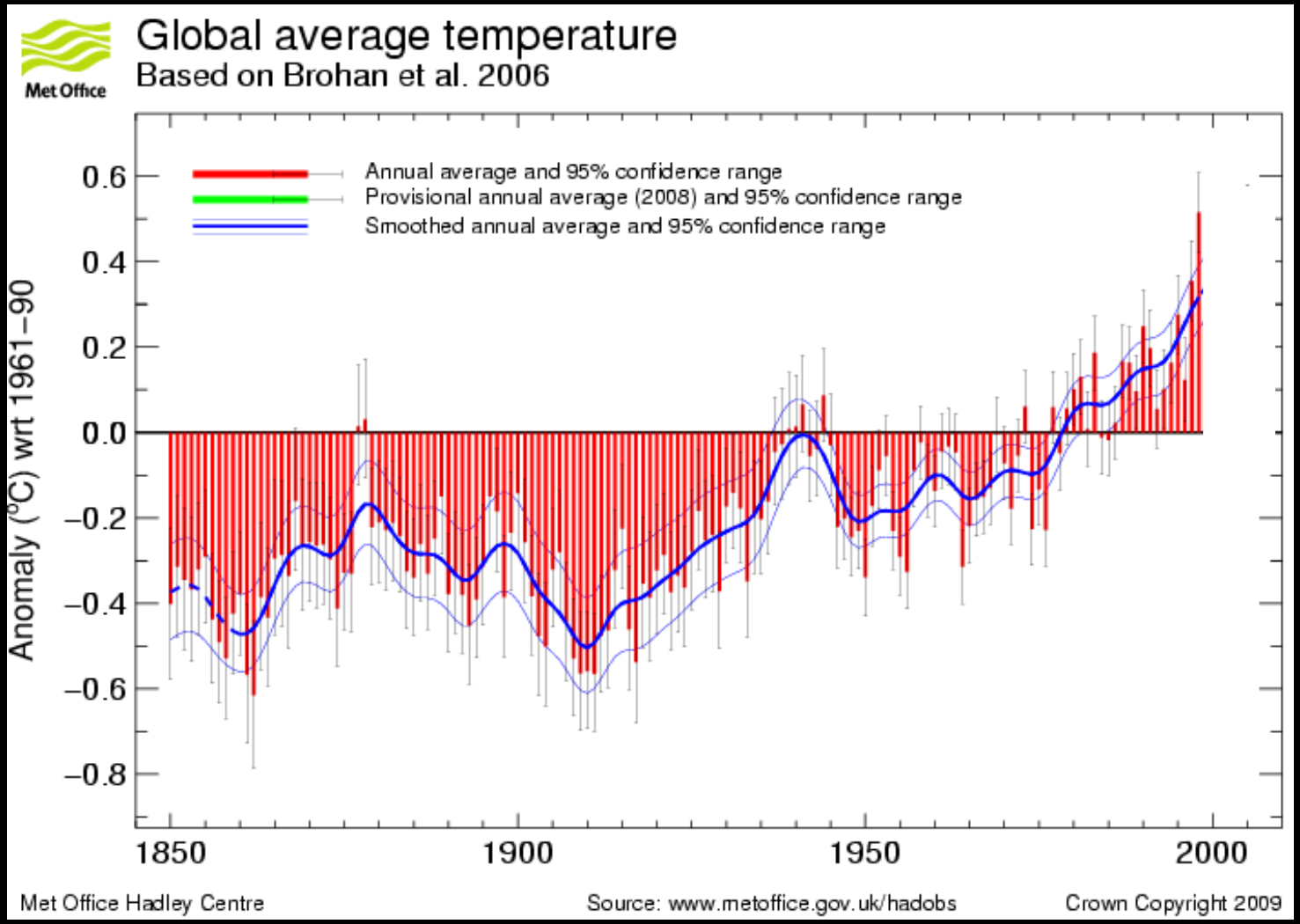
In last 100 yrs, sea level rose 8 inches



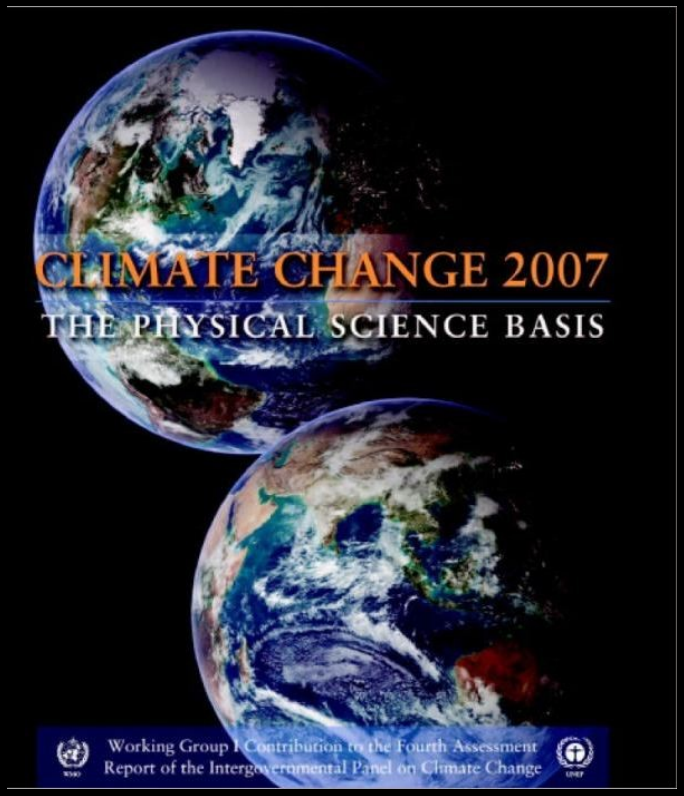
Calculations by the Hadley Center for Climate Change, Met Office UK

Tons CO_2 per $1000




Met Office
Global average temperature
Based on Brohan et al. 2006
Annual average and 95% confidence range
Provisional annual average (2008) and 95% confidence range
Smoothed annual average and 95% confidence range
Anomaly (°C) wrt 1961–90
0.6
0.4
0.2
0.0
–0.2
–0.4
–0.6
–0.8
1850
1900
1950
2000
Met Office Hadley Centre
Source: www.metoffice.gov.uk/hadobs
Crown Copyright 2009

THIS is the consensus:



IPCC 2007

"The observed widespread warming of the atmosphere and ocean, together with ice mass loss, support the conclusion that it is extremely unlikely that global climate change of the past ***fifty years*** can be explained without external forcing, and very likely [90%] that it is not due to known natural causes alone."

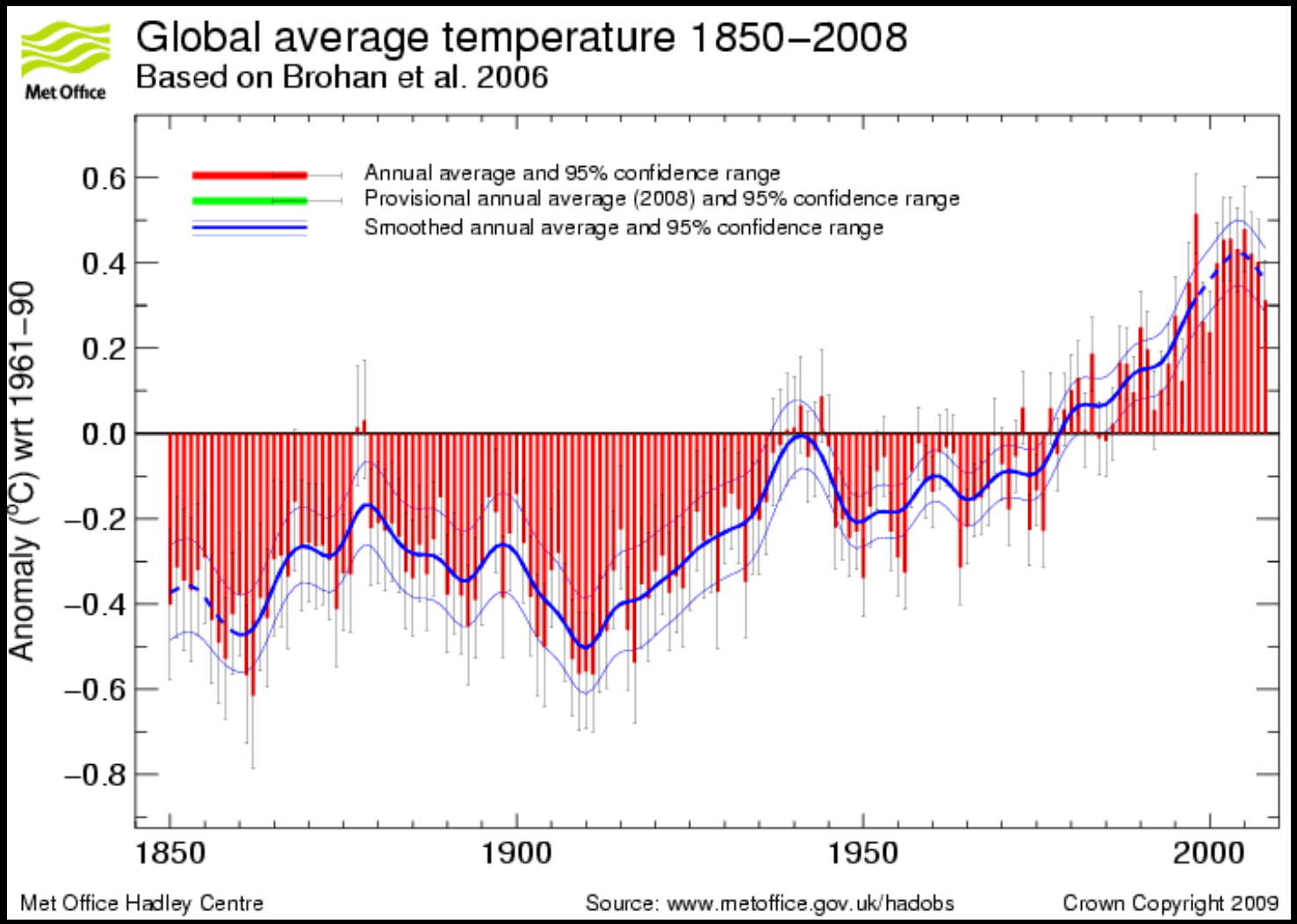

Met Office
Global average temperature 1850–2008
Based on Brohan et al. 2006
Annual average and 95% confidence range
Provisional annual average (2008) and 95% confidence range
Smoothed annual average and 95% confidence range
Anomaly (°C) wrt 1961–90
0.6
0.4
0.2
0.0
–0.2
–0.4
–0.6
–0.8
1850
1900
1950
2000
Met Office Hadley Centre
Source: www.metoffice.gov.uk/hadobs
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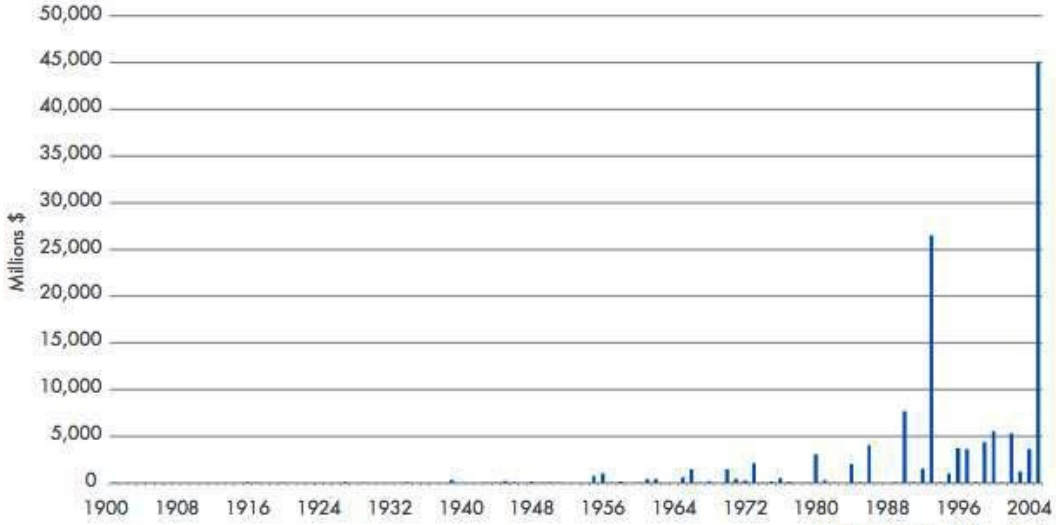
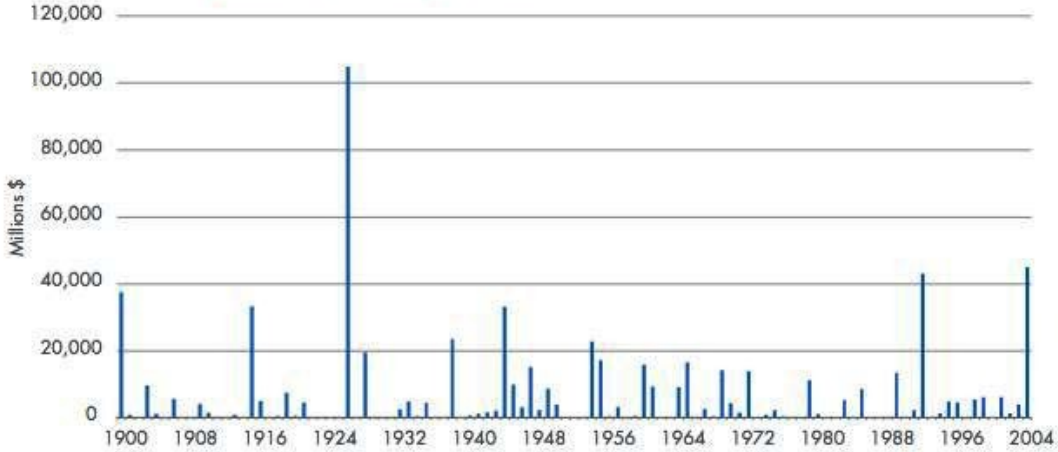
Figure 11: Nominal U.S. Monetary Damages from Hurricanes, 1900–2004



(Source: Pielke & Landsea[7])

Figure 12: U.S. Hurricane Monetary Damages, Adjusted for Inflation, Population Growth, & Wealth



(Source: Pielke & Landsea)

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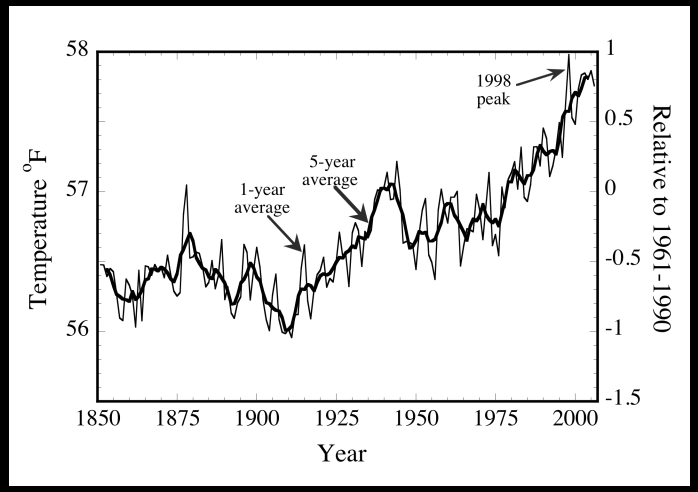
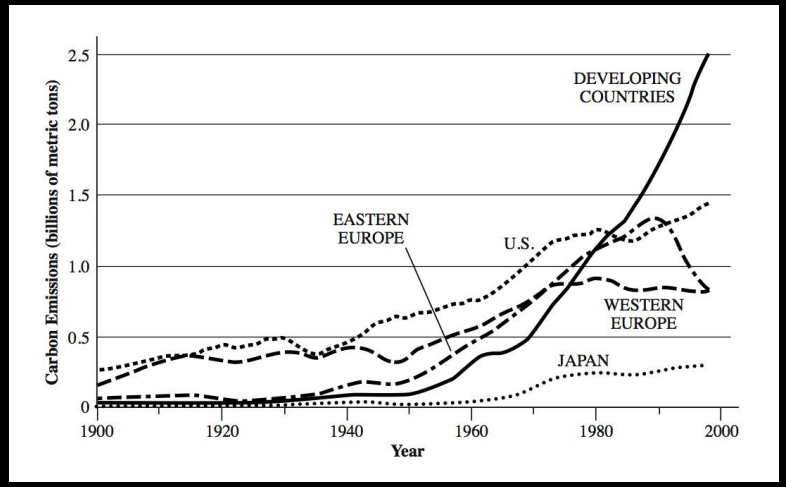




The bottom lines:

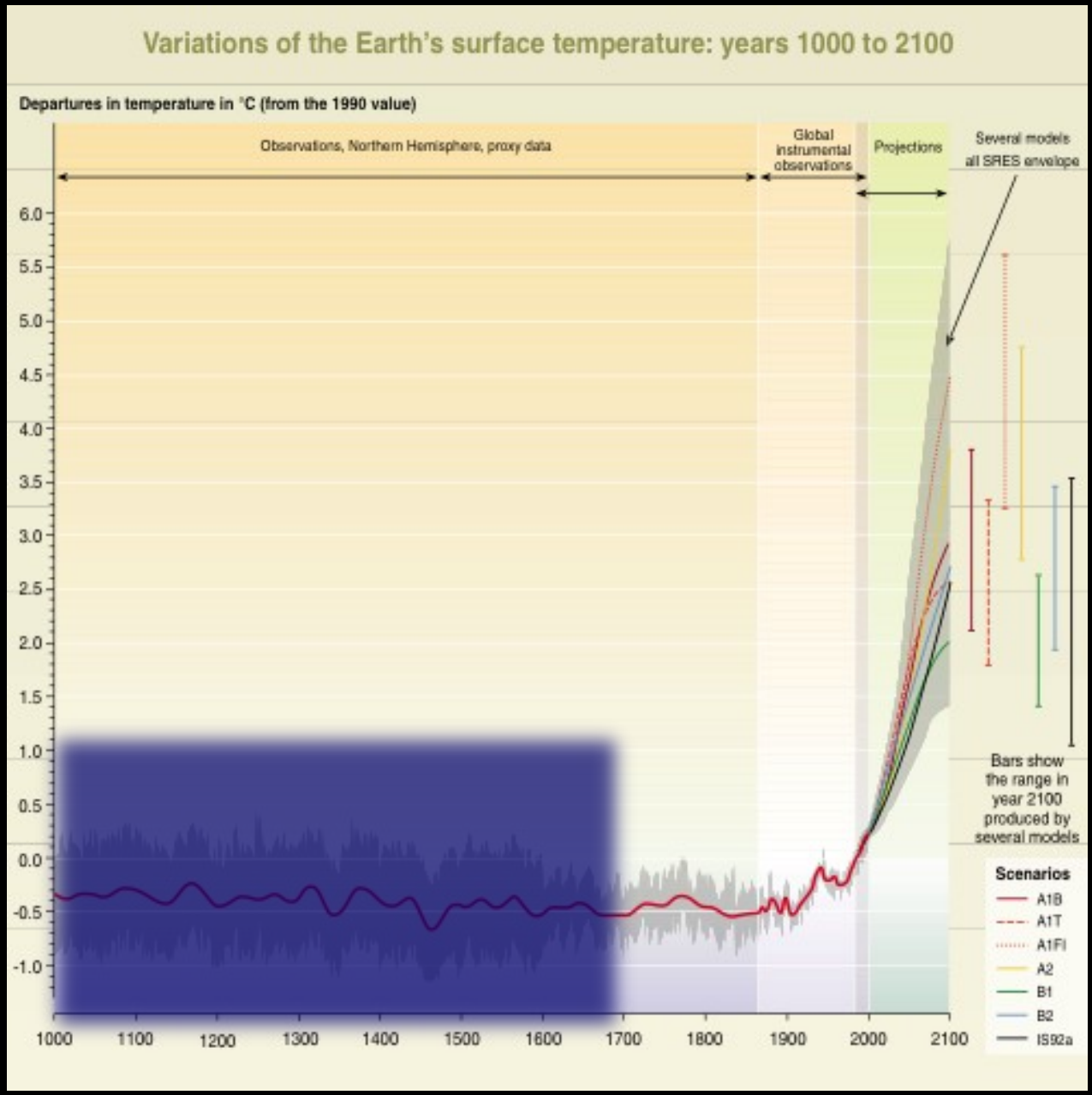
We need the full spectrum:
- solar
- natural gas
- wind
- clean coal

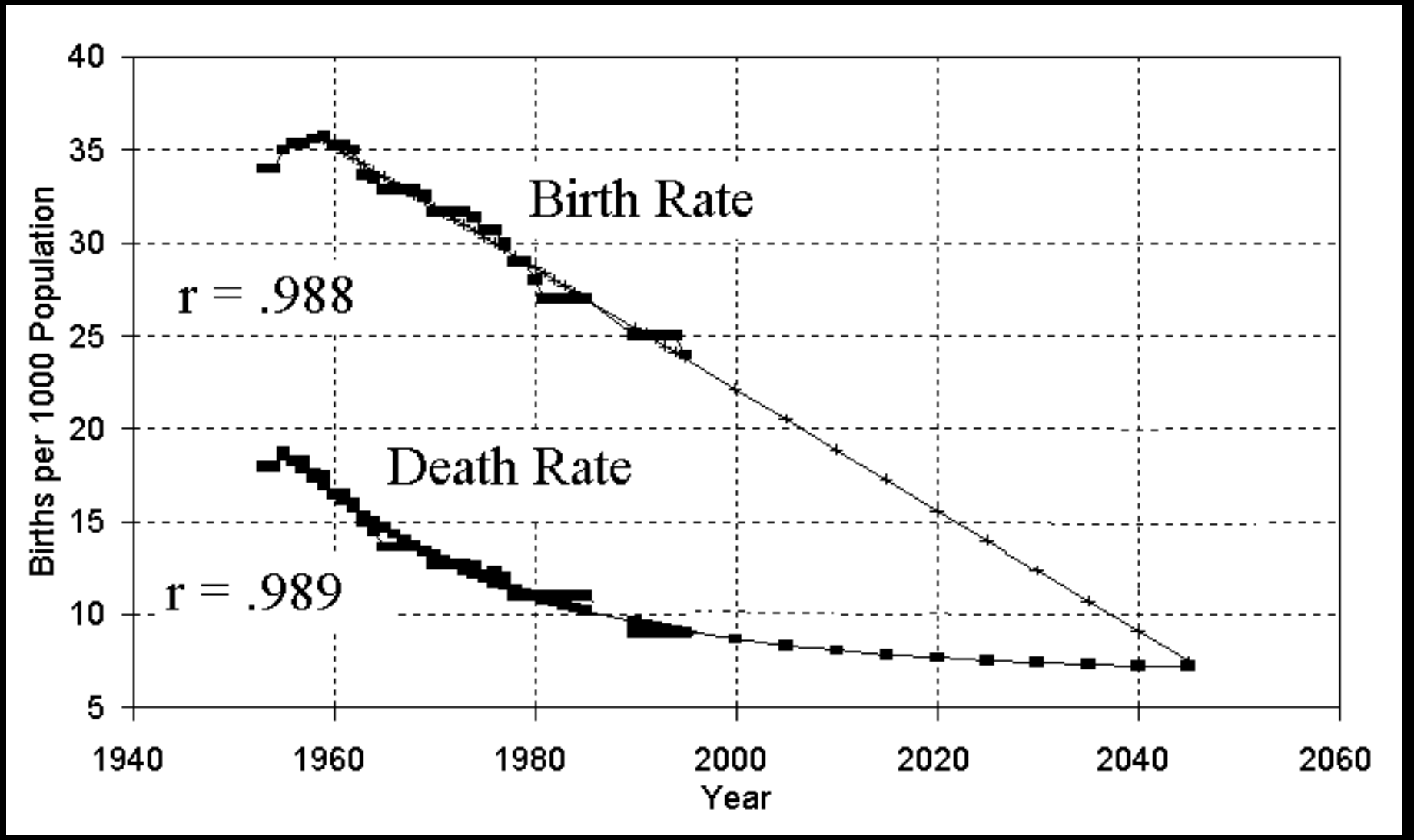
Everyone needs to know this stuff.

Physics is nonpartisan
and non-denominational.

Should not need to be
taught with spin.

Monthly Fireside Chats?
A *real* President's Science Advisory Committee?


Variations of the Earth's surface temperature: years 1000 to 2100
Departures in temperature in °C (from the 1990 value)
Observations, Northern Hemisphere, proxy data
Global instrumental observations
Projections
Several models all SRES envelope
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
Bars show the range in year 2100 produced by several models
Scenarios
A1B
A1T
A1FI
A2
B1
B2
IS92a


Births per 1000 Population
40
35
30
25
20
15
10
5
1940
1960
1980
2000
2020
2040
2060
Year
Birth Rate
r = .988
Death Rate
r = .989

1 Megaton Nuke hits Central Manhattan

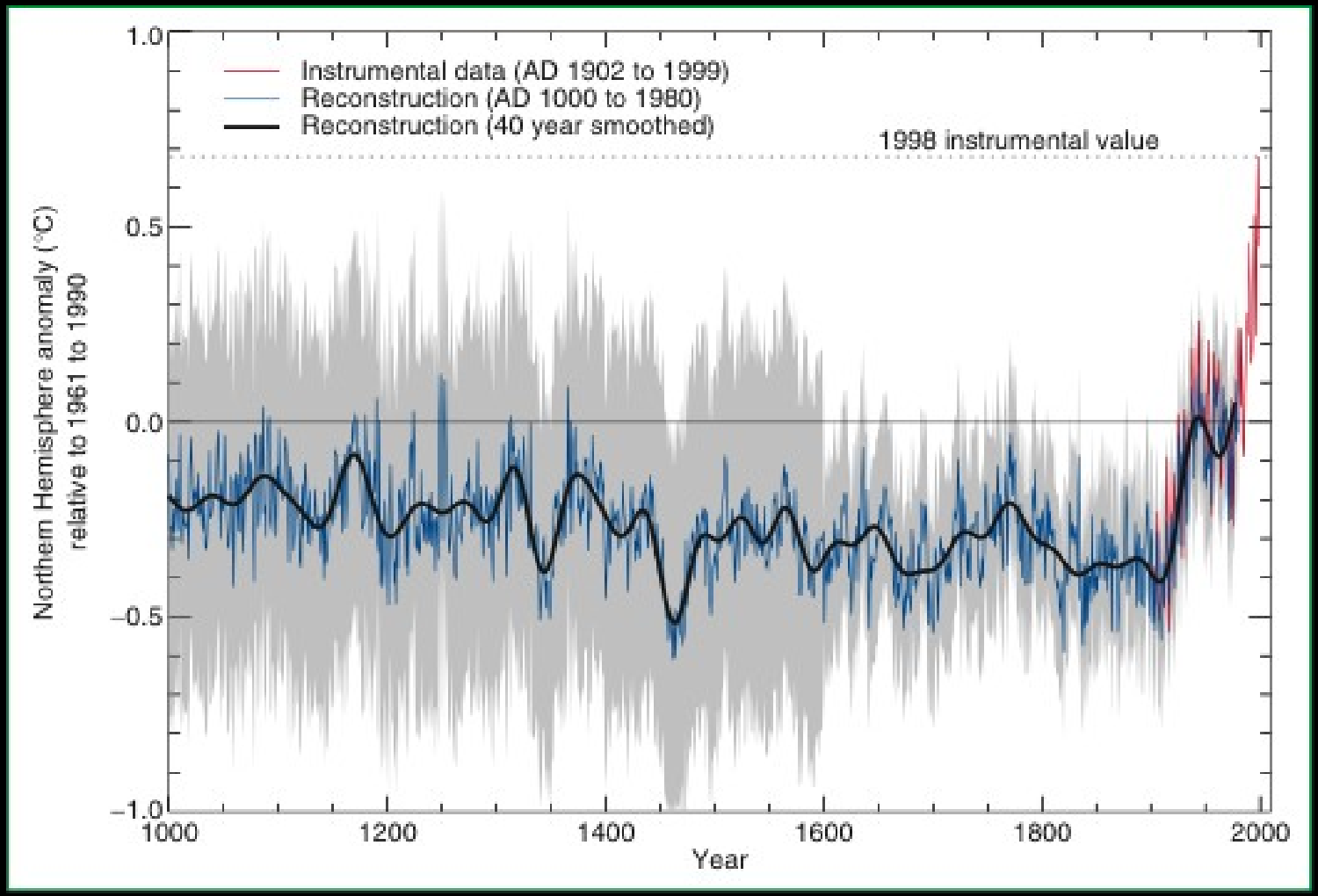
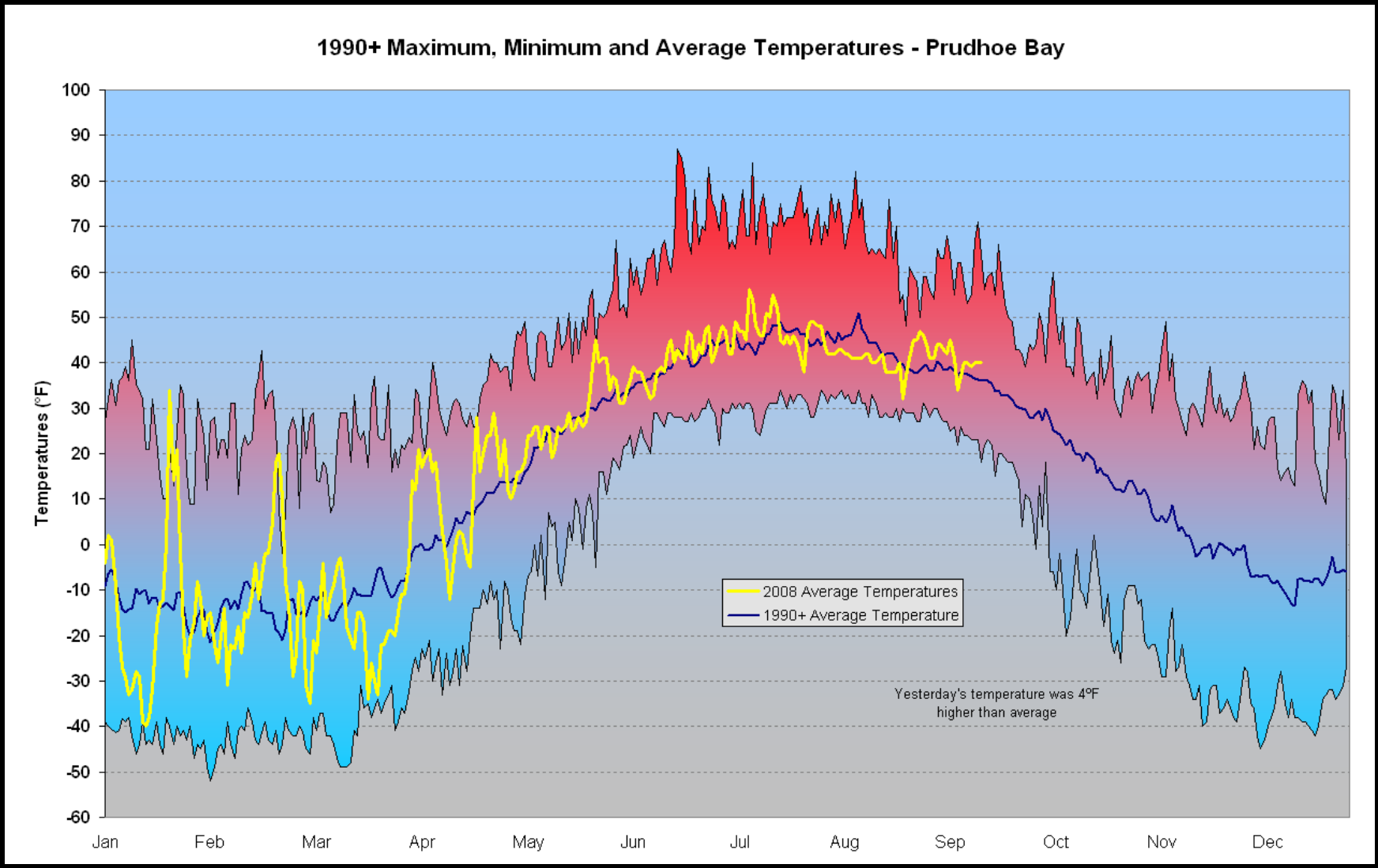
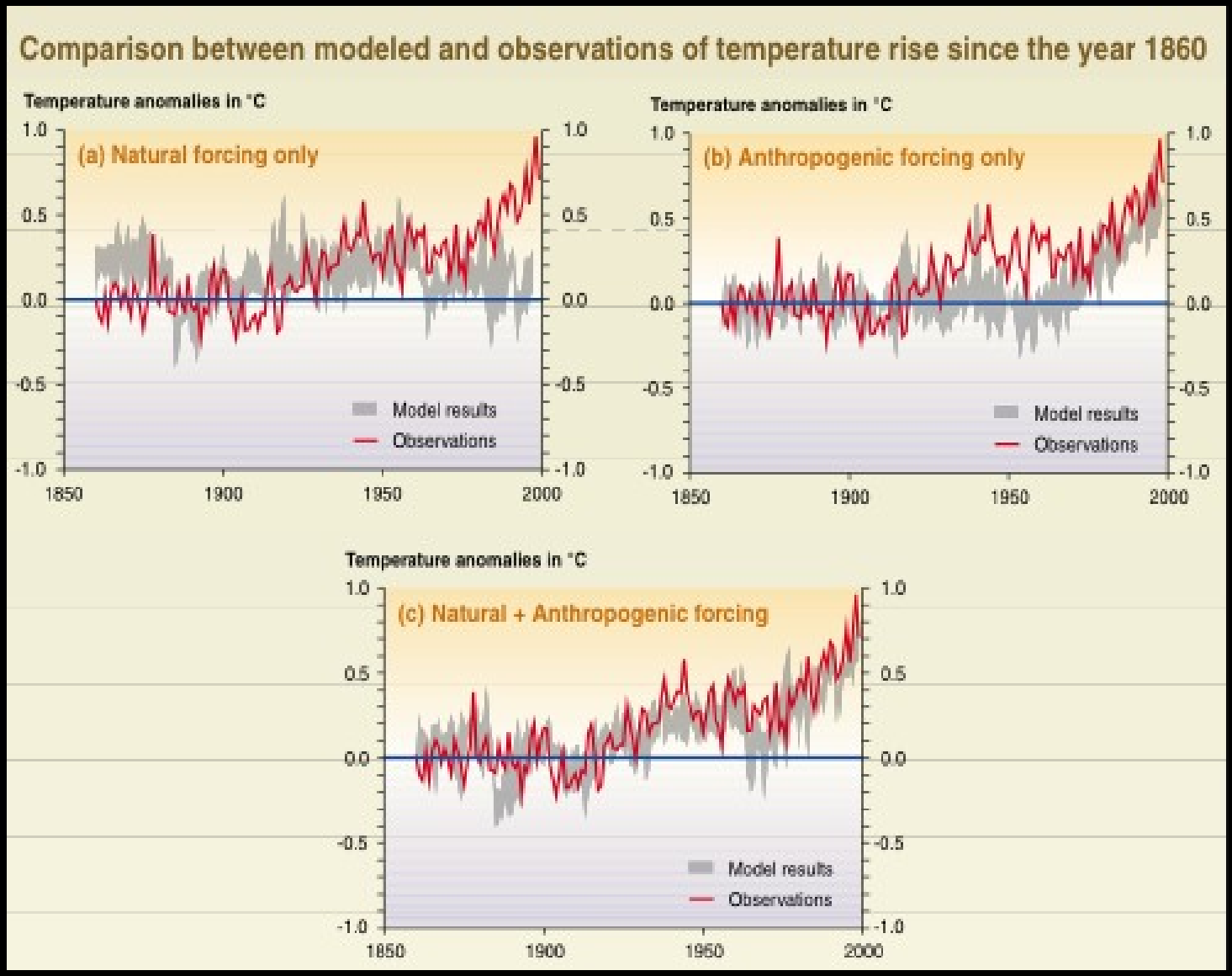


Figure 5: Millennial Northern Hemisphere (NH) temperature reconstruction (blue – tree rings, corals, ice cores, and historical records) and instrumental data (red) from AD 1000 to 1999. Smoother version of NH series (black), and two standard error limits (gray shaded) are shown. [Based on Figure 2.20]


1990+ Maximum, Minimum and Average Temperatures - Prudhoe Bay
Temperatures (°F)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2008 Average Temperatures
1990+ Average Temperature
Yesterday's temperature was 4ºF
higher than average


Comparison between modeled and observations of temperature rise since the year 1860
Temperature anomalies in °C
(a) Natural forcing only
Model results
Observations
Temperature anomalies in °C
(b) Anthropogenic forcing only
Model results
Observations
Temperature anomalies in °C
(c) Natural + Anthropogenic forcing
Model results
Observations
1.0
0.5
0.0
-0.5
-1.0
1850
1900
1950
2000

The public needs to know this stuff.

The public needs to know this stuff.

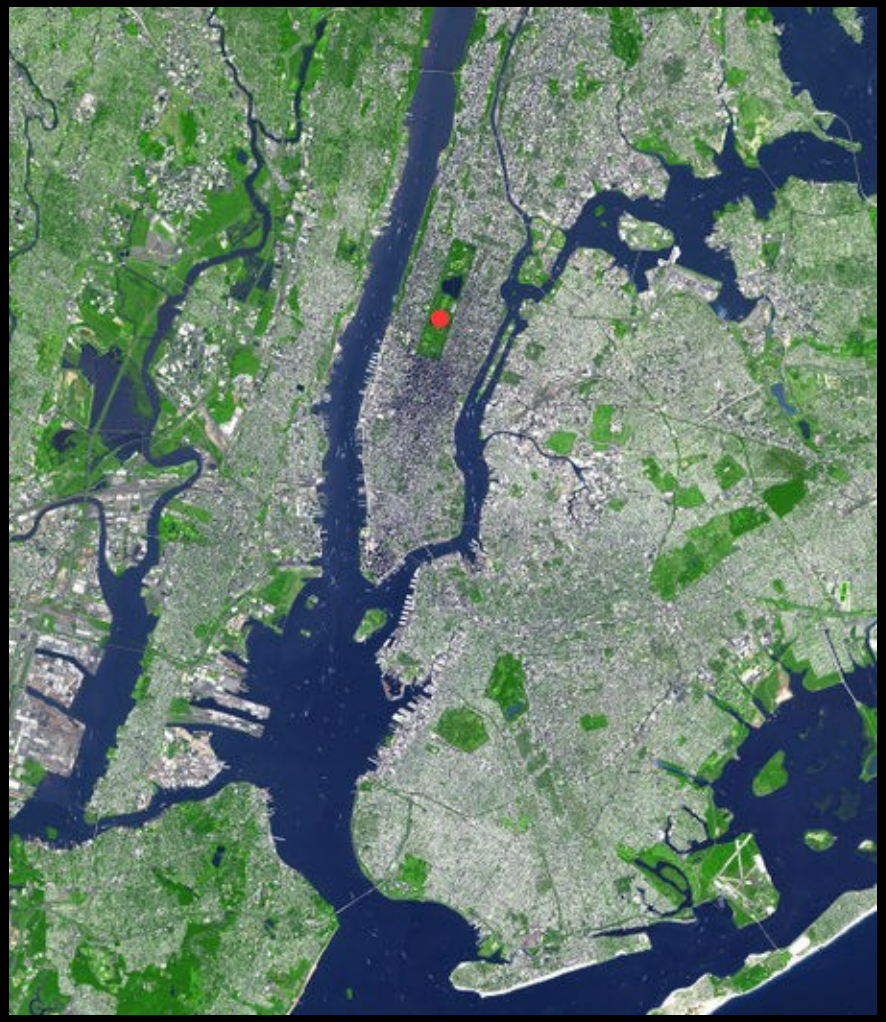
Physics is nonpartisan and non-denominational.

The public needs to know this stuff.

Physics is nonpartisan and non-denominational.

Physics does not need to be taught with spin.

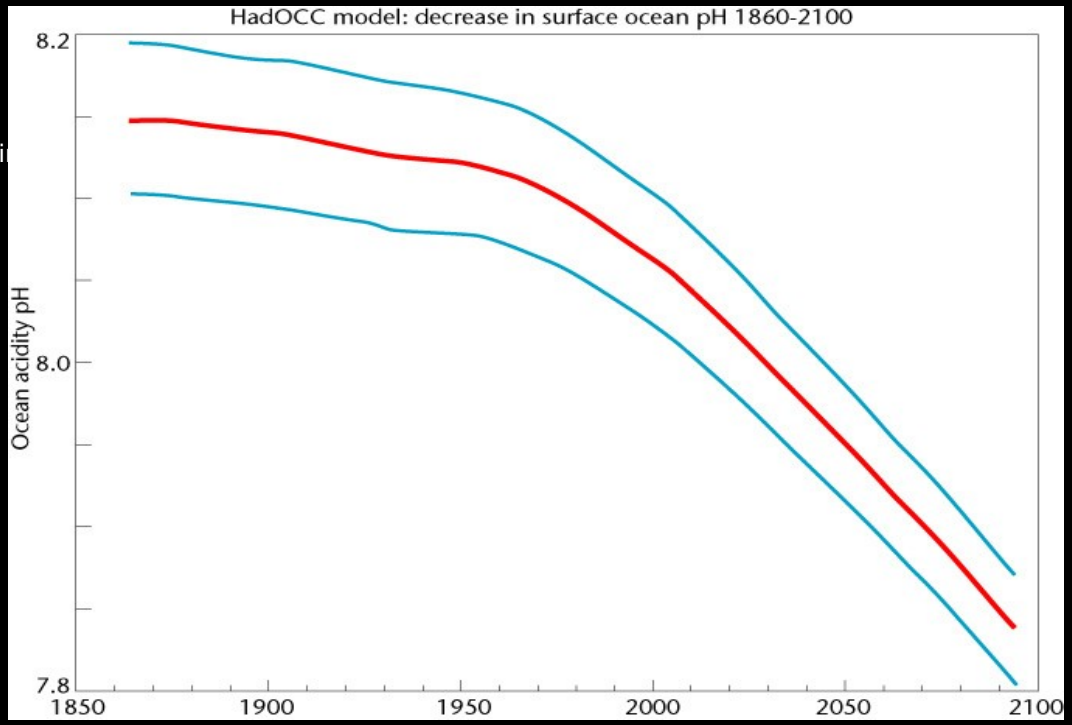
North Korean Nuke hits Central Park



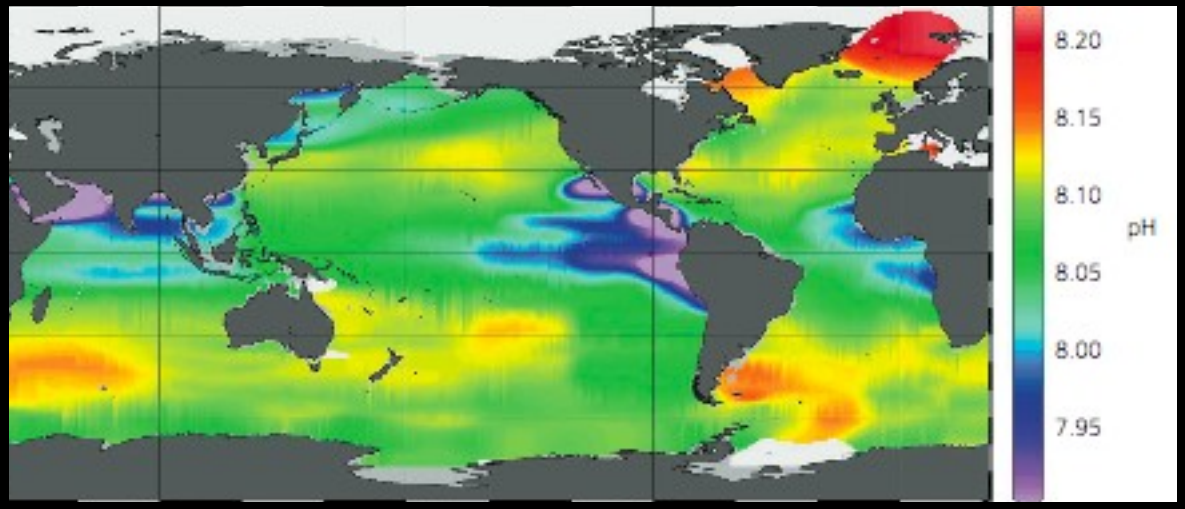
Al Gore: the evidence that humans are responsible for all of the damaging global warming of the past 120 years is clear and incontrovertible.

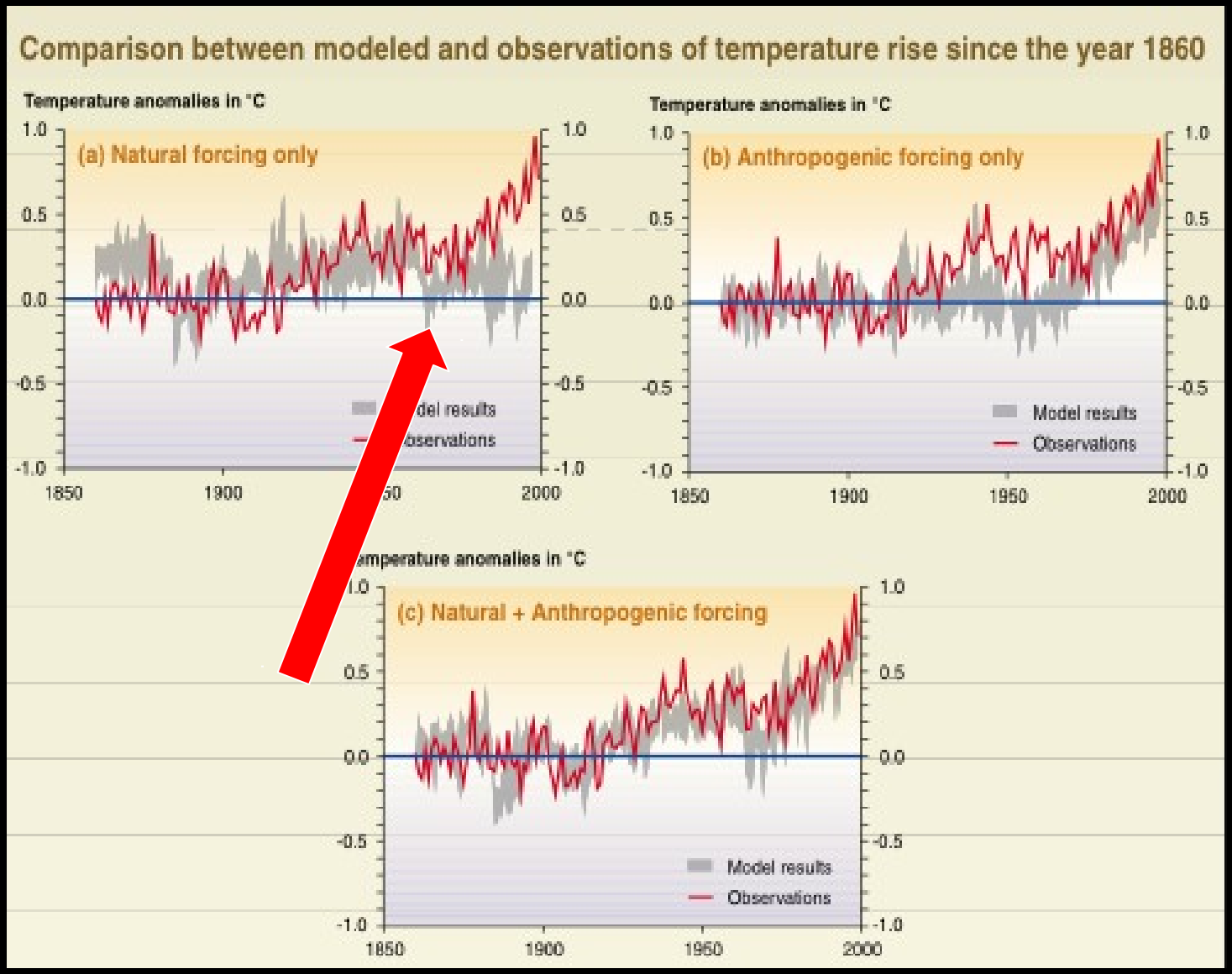
IPCC: it is very likely (90% chance) that humans caused some of the 1° F warming of the past 50 years.

The di



Acidify the Oceans?

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Model results
Observations
Temperature anomalies in °C
(c) Natural + Anthropogenic forcing
Model results
Observations
1.0
0.5
0.0
-0.5
-1.0
1850
1900
1950
2000

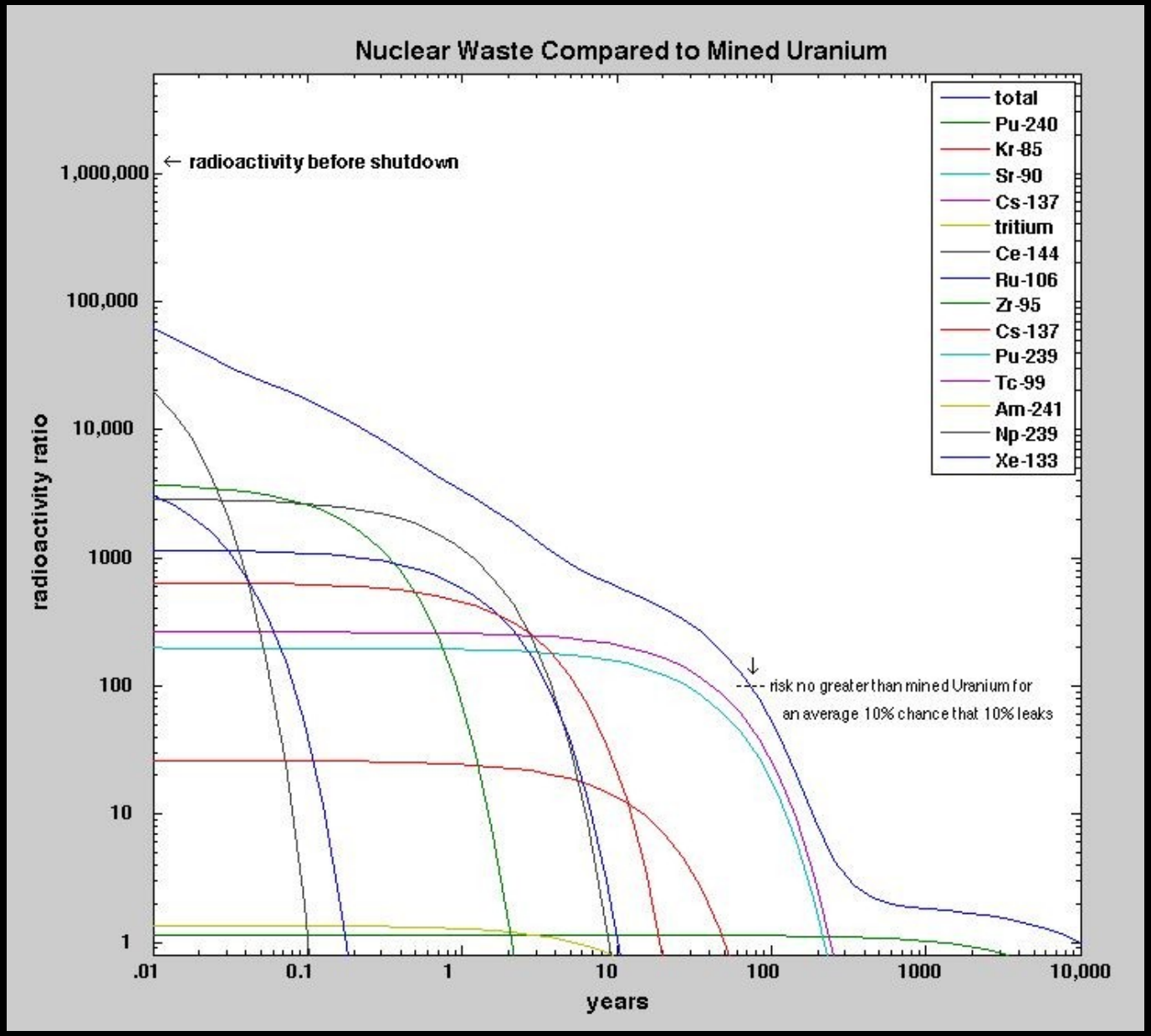
Role of clouds

	High thin	High thick	middle thin	middle thick	all low clouds	Total
global fraction (%)	+10.1	+8.6	+10.7	+7.3	+26.6	+63
Forcing Albedo (W/m^2)	-4.1	-15.6	-3.7	-9.9	-20.2	-53.5
Outgoing IR (W/m^2)	+6.5	+8.6	+4.8	+2.4	+3.5	+25.8
Net forcing (W/m^2)	2.4	-7.0	+1.1	-7.5	-16.7	-27.7

compare insolation variations = 18 W/m^2 rms

Richard A Muller
UC Berkeley

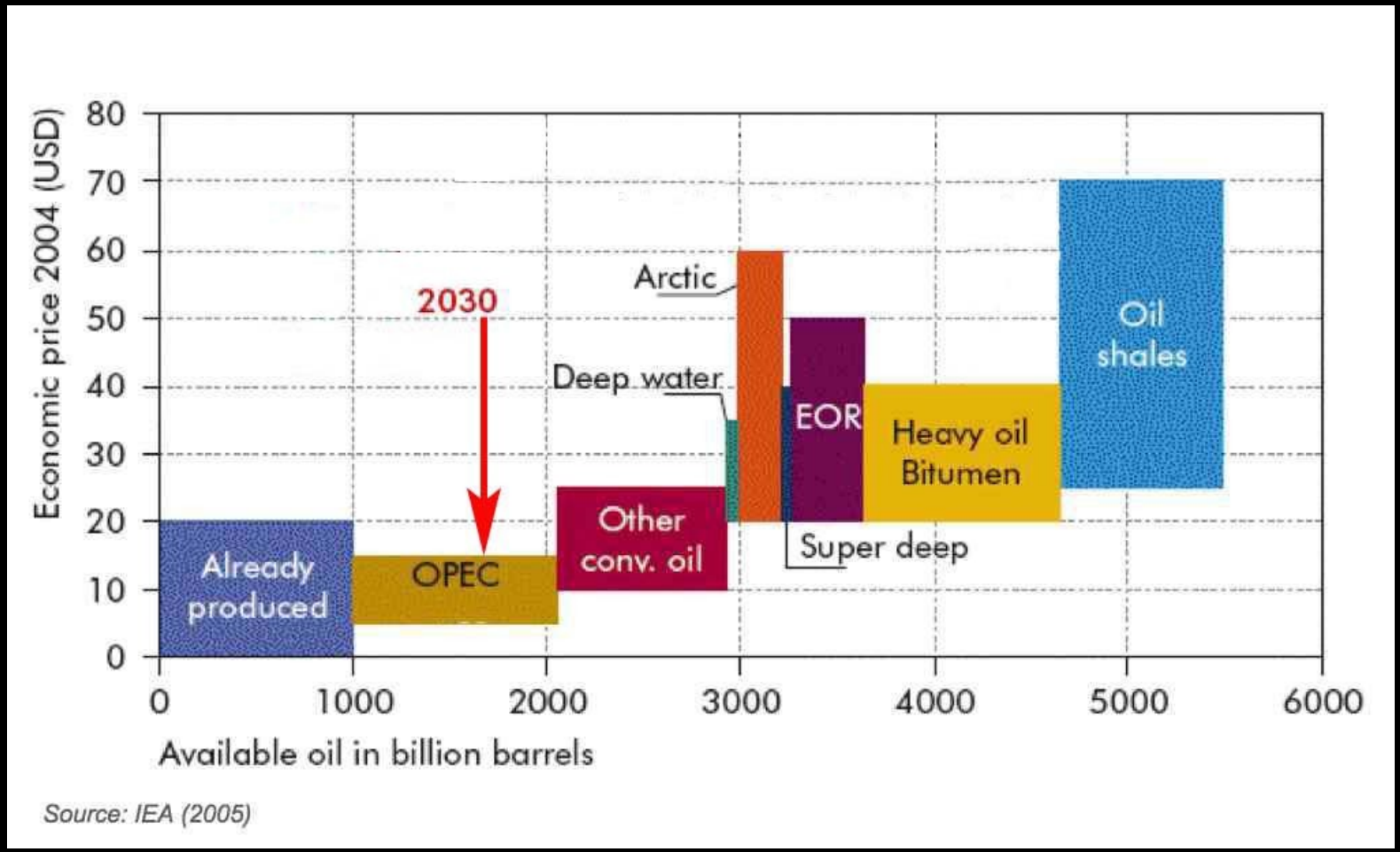
Nuclear Waste

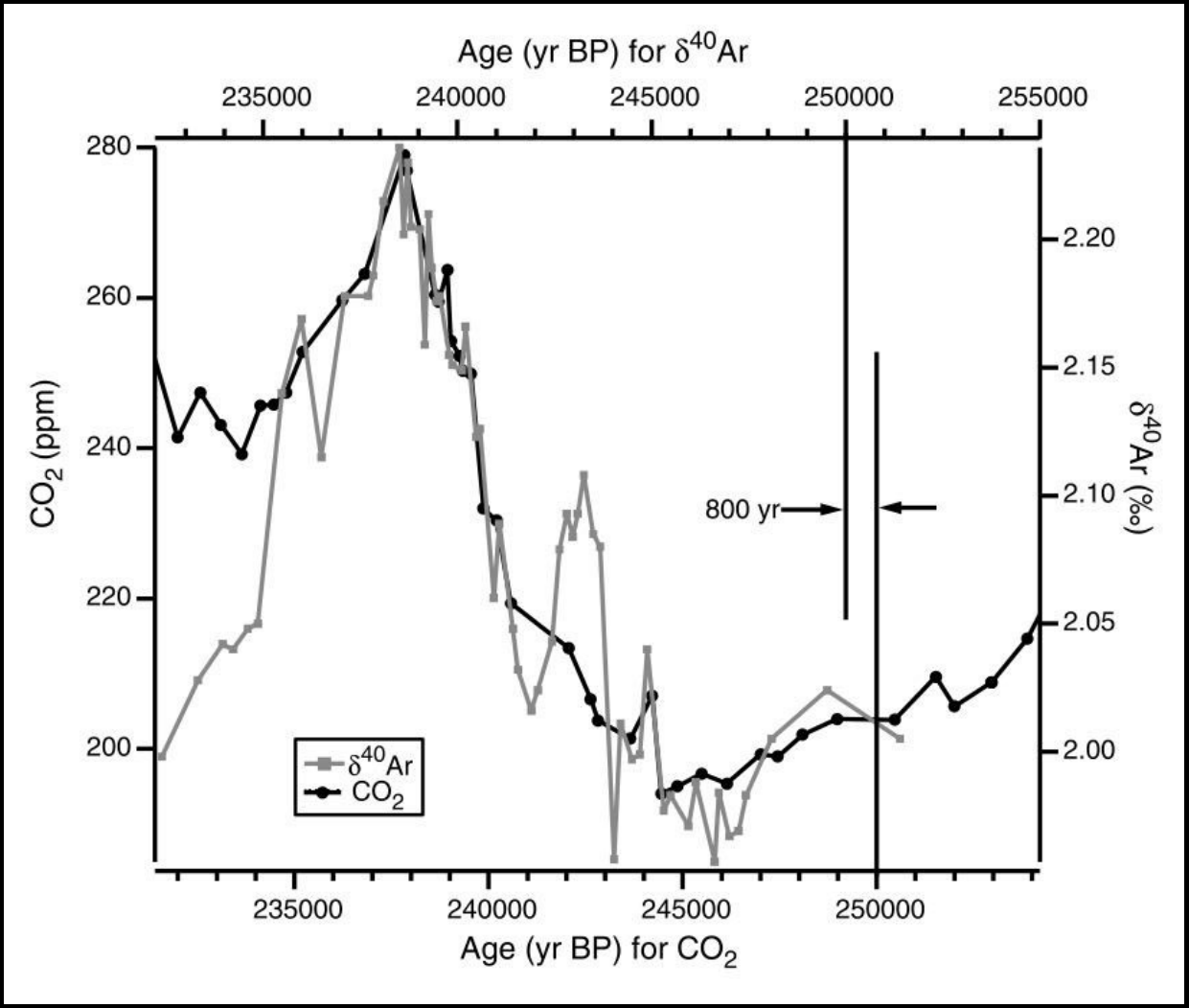


New Solar Cells

	Group	Material	Present (MW)	Additional (MW)	Total (MW)	Group	Material	Present (MW)	Additional (MW)	Total (MW)	Totals	Grand Total
USA	First Solar	CdTe	90	–	90	Nanosolar	CIS	–	430	430	1127	3704
	Uni-Solar	a-Si	60	240	300	AVA Solar	CdTe	3	20	3		
	MiaSole	CIS	5	50	55	Nano PV	a-Si	–	4	4		
	Global Solar	CIS	3	50	53	QuStar	a-Si	–	40	40		
	EPV	a-Si	2	25	27	Primestar Solar	CdTe	–	20	20		
	Daystar Technologies	CIS	1	10	11	SoloPower	CIS	–	20	20		
	Power Film	a-Si	1	10	11	ISET	CIS	–	3	3		
	Ascent Solar	CIS	2	20	27	MWOE Solar	a-Si	–	3	3		
						Heliovolt	CIS	–	20	20		
JAPAN	Kaneka	a-Si	30	60	70	MHI	a-Si	14	56	70	1312	
	Showa Shell	CIS	30	60	60	Kanto Sanyo	a-Si	7	–	7		
	Sharp	a-Si	15	1000	15	Honda	CIS	3	27	30		
	Fuji	a-Si	15	25	40							
EUROPE	First Solar	CdTe	120	700	120	AMI	a-Si	–	160	160	793	
	CSG Solar	Thin-Si	10	15	25	Johanna Solar Tech	CIS	–	30	30		
	Würth Solar	CIS	3	15	18	Brilliant	a-Si	–	25	25		
	Antec Solar	CdTe	10	–	10	Solibro	CIS	–	30	30		
	Schott Solar	a-Si	3	27	30	Global Solar	CIS	–	30	30		
	ICP Solar Tech	a-Si	3	–	3	Helio Grid	a-Si	–	50	50		
	Solar Cells	a-Si	1	–	1	SunFilm	a-Si	–	60	60		
	Free Energy	a-Si	1	–	1	T.J. Solar	a-Si	–	40	40		
	Solar Plus	a-Si	–	5	5	Signet Solar	a-Si	–	20	20		
	Sulfur Cells	CIS	5	–	5	Oyaco	CdTe	–	25	25		
	Alex Solar	CIS	–	30	30	Avancis	CIS	–	20	20		
	Enel	a-Si	–	40	40	Odersun	CIS	–	5	5		
						Schuelen Solar	CIS	–	10	10		
ASIA	First Solar	CdTe	–	220	220	GET	a-Si	–	40	40	472	
	Bangkok Solar	a-Si	7	–	7	Kenwin Tech	a-Si	–	35	35		
	Sinonar	a-Si	3	–	3	Mosen Solar	a-Si	–	20	20		
	T.J. Solar Cell	a-Si	2	–	2	Solar Mech	a-Si	–	20	20		
	Soltech	a-Si	15	–	15	Topray Solar	a-Si	20	–	20		
	Suntech Power	a-Si	–	50	50	CMC	a-Si	–	40	40		

from HS Ullal and B von Roedern, 2007


Economic price 2004 (USD)
80
70
60
50
40
30
20
10
0
2030
Arctic
Deep water
EOR
Heavy oil
Bitumen
Oil
shales
Other
conv. oil
Super deep
Already
produced
OPEC
0
1000
2000
3000
4000
5000
6000
Available oil in billion barrels
Source: IEA (2005)

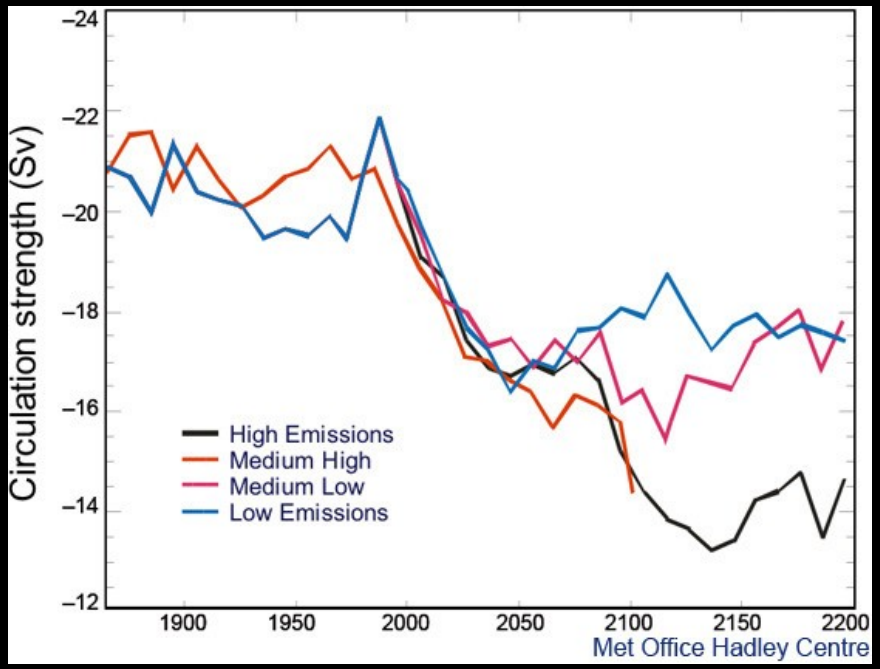


Temperature change precedes CO_2 change by 800 ± 200 yrs

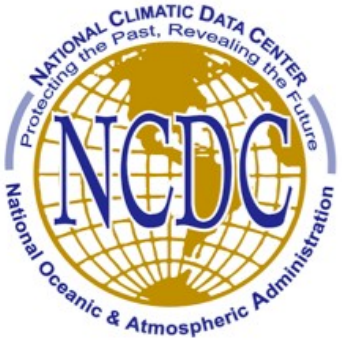
Richard A Muller
UC Berkeley

N. Caillon et al., *Science* vol 299**, 1728, 14 Ma**

Thermohaline Circulation Turn off?



- Atlantic ocean circulation predicted to decline but not switch off



Climate Monitoring Branch
NOAA/NESDIS/NCDC

The Climate of 2006

Global Temperature Anomalies
Global Temperature Anomaly Time Series
Global Temperature and Precipitation Anomaly Maps
Contiguous U.S. Temperature and Precipitation Time Series
U.S. Statewide Temperature and Precipitation Rankings
U.S. Divisional Temperature and Precipitation Rankings
U.S. Wildland Fire Maps
U.S. Strong to Violent Tornadoes
Sea Surface Temperature Anomaly Time Series
Global and U.S. Significant Event Maps

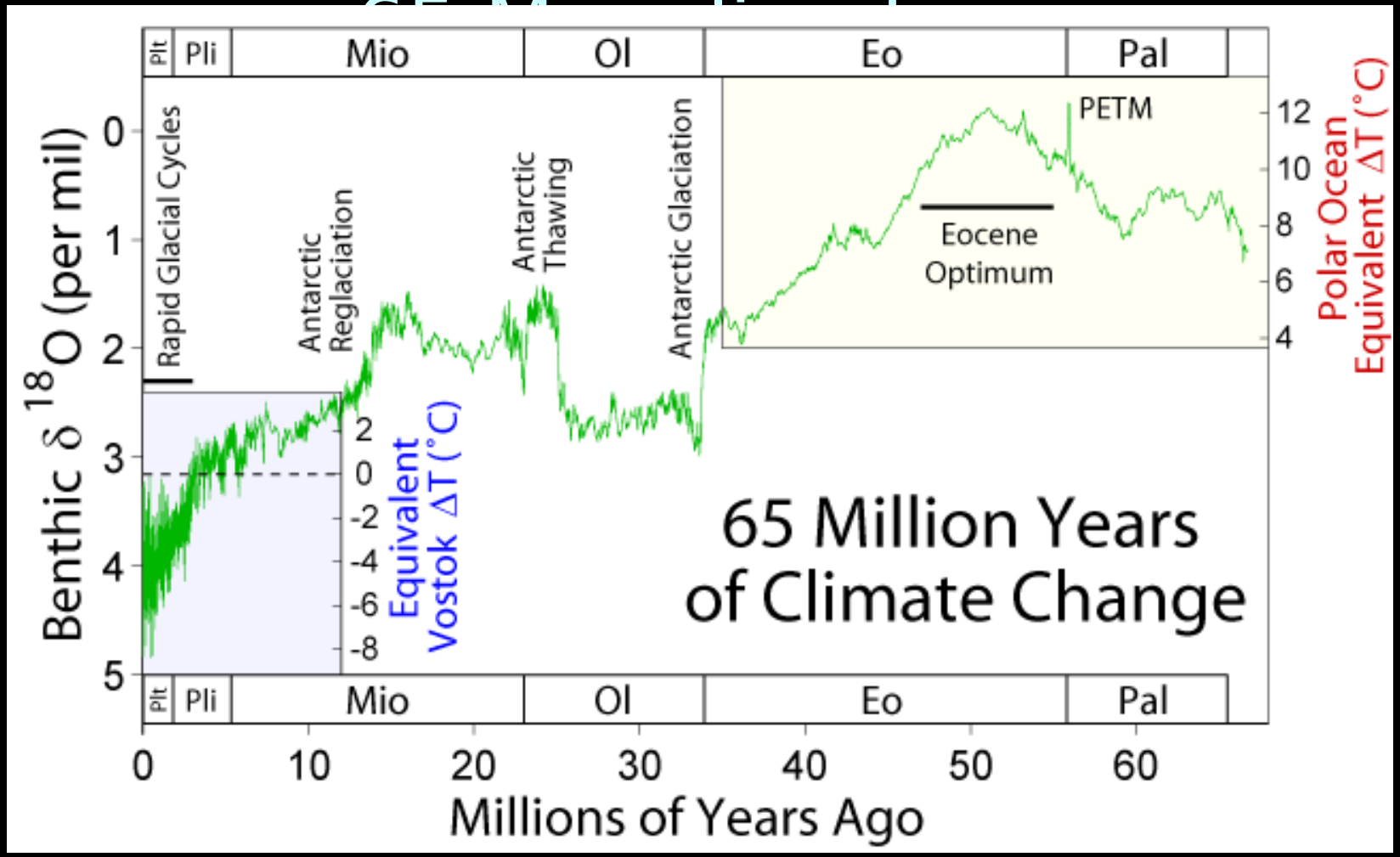
All products are available online at:
http://www.ncdc.noaa.gov/oa/climate/research/monitoring.html

of 2006

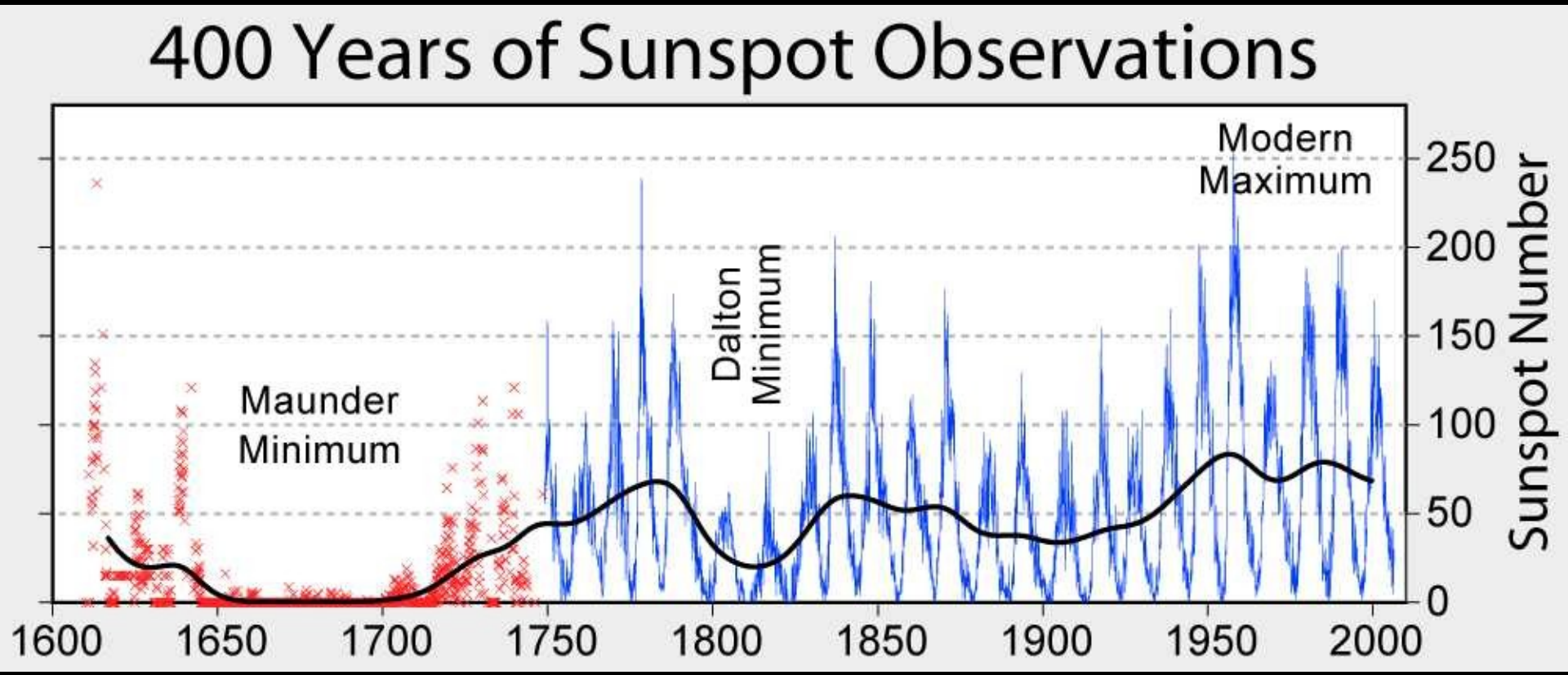
Richard A Muller
UC Berkeley

wildfires - both plots

Richard A Muller
UC Berkeley



plot by Robert Rohde, Wikipedia



Richard A Muller
UC Berkeley

Intensification of Pacific storm track linked to Asian pollution

Renyi Zhang*†, Guohui Li*, Jiwen Fan*, Dong L. Wu‡, and Mario J. Molina†§

*Department of Atmospheric Sciences, Texas A&M University, College Station, TX 77843; †Microwave Atmospheric Sciences, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109; and §Department of Chemistry and Biochemistry, University of California at San Diego, La Jolla, CA 92093

Contributed by Mario J. Molina, January 23, 2007 (sent for review January 7, 2007)

Indirect radiative forcing of atmospheric aerosols by modification of cloud processes poses the largest uncertainty in climate prediction. We show here a trend of increasing deep convective clouds over the Pacific Ocean in winter from long-term satellite cloud measurements (1984–2005). Simulations with a cloud-resolving weather research and forecast model reveal that the increased deep convective clouds are reproduced when accounting for the aerosol effect from the Asian pollution outflow, which leads to large-scale enhanced convection and precipitation and hence an intensifed storm track over the Pacific. We suggest that the wintertime Pacific is highly vulnerable to the aerosol–cloud interaction because of favorable cloud dynamical and microphysical conditions from the coupling between the Pacific storm track and Asian pollution outflow. The intensified Pacific storm track is climatically significant and represents possibly the first detected climate signal of the aerosol–cloud interaction associated with anthropogenic pollution. In addition to radiative forcing on climate, intensification of the Pacific storm track likely impacts the global general circulation due to its fundamental role in meridional heat transport and forcing of stationary waves.

aerosols | climate | clouds

Atmospheric aerosols influence cloud development, duration, or precipitation (1–6). This process, known as the aerosol indirect effect, alters the cloud albedo and exerts an important radiative forcing on climate (2). Current understanding of the aerosol indirect effect remains highly uncertain, constituting the greatest uncertainty in climate prediction (2). Cloud processes are determined by complex thermodynamic, dynamical, and microphysical processes and their interactions (5). Following the pioneer work by Twomey (1), there has been accumulative evidence in support of the qualitative conclusion that high aerosol levels reduce the cloud droplet size for a fixed liquid water content (6, 7). Reduced cloud droplet sizes delay the onset of precipitation, leading to invigoration and restructuring of clouds. Measurements of heavy smoke forest fires in the Amazon found suppression of low-level rainout and aerosol washout, which allows transport of water and smoke to upper levels, causing more intensive thunderstorms and release of more latent heat higher in the atmosphere (7). Recent analyses of satellite measurements of the aerosol optical depth and cloud top pressure also suggested a correlation between the presence of aerosols and the structural properties of clouds, indicating a likely cloud invigoration by pollution (8). In addition, enhanced deep convection and mixed-phase processes associated with urban pollution have been implicated in elevated electrification and lightning activities in thunderstorms (9–11).

Increasing pollution levels in Asia and associated outflows have raised considerable concerns because of their potential impact on regional and global climate (12, 13). Notable decadal changes in regional aerosol optical depths during winter months in Asia have been observed from satellite Total Ozone Mapping Spectrometer (TOMS) measurements (14) and can be attributed to dramatically increased SO_2 and soot emissions from fossil-fuel burning. In this report, we present an analysis of long-term satellite cloud measurements, emphasizing the north Pacific region, where most transPacific pollution transport occurs (15).

Results and Discussion

The data used in this study are monthly mean cloudiness from the International Satellite Cloud Climatology Project (ISCCP), which contains a long-term record with a global coverage. The ISCCP data correspond to cloud statistics from 1984 to 2005 and are derived by using all operational geostationary and polar orbiting weather satellites (16). The data are a merger of advanced very high-resolution radiometer polar orbiter data two to four times per day, with available geosynchronous observations superimposed. The ISCCP uses the channels common to weather satellites, the visible channel at 0.6 μm and the infrared window at 11 μm, to detect clouds and measure their optical depths. We considered deep convective clouds (DCCs) from the ISCCP data, classified by the measured values of the cloud optical thickness (23–379) and cloud top pressure (440–50 mbar). Comparison of the amount of optically thick clouds between ISCCP and high-resolution infrared sounder (HIRS) showed a good agreement (17) [see supporting information (SI) *Text*].

Figure 1 displays January distributions of ISCCP DCC amounts averaged during the periods of 1984–1993 and 1994–2005. A prominent feature over the Pacific Ocean lies in the relatively high DCC amounts (Fig. 1 *a* and *b*), which extend mostly from southwest to northeast. The DCC pattern coincides with the winter Pacific storm track. Over the northwest Pacific, the near-surface meridional temperature gradient is high in midlatitudes, where the cold, dry, monsoonal air encounters the warm air mass to the south. Also, there is an abundant supply of heat and moisture from the warm ocean surface to the monsoonal air. The two effects sustain high lower tropospheric baroclinicity, which facilitates migrating baroclinic eddies to form a storm track downstream (18), characterized by a belt of local maximal precipitation across almost the entire north Pacific (19). The Pacific storm track is fundamental to the global general circulation by relaxing the Earth's temperature gradient through sensible heat transport to higher latitudes and the forcing of stationary waves (18).

Author contributions: R.Z. designed research; R.Z., G.L., and J.F. performed research; R.Z., G.L., D.L.W., and M.J.M. analyzed data; and R.Z. wrote the paper.

The authors declare no conflict of interest.

Freely available online through the PNAS open access option.

Abbreviations: TOMS, Total Ozone Mapping Spectrometer; ISCCP, International Satellite Cloud Climatology Project; DCC, deep convective cloud; HIRS, high-resolution infrared sounder; CR-WRF, cloud-resolving weather research and forecasting.

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This article contains supporting information online at www.pnas.org/cgi/content/full/0700618104/DC1.

Global impact of Asia's pollution

Industrial pollution coming from Asia is having a wider effect on global weather and climate than previously realised, research suggests.

Smog is having a global impact on weather and climate, scientists say

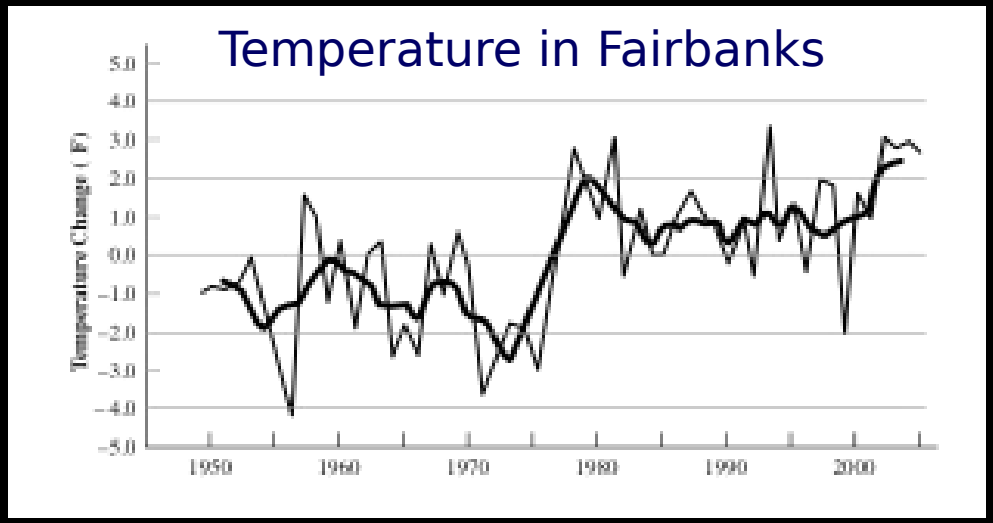
The "Asian haze" of soot is boosting storms in the Pacific, scientists find.

It is also enhancing the growth of large clouds, which play a key role in regulating climate globally.

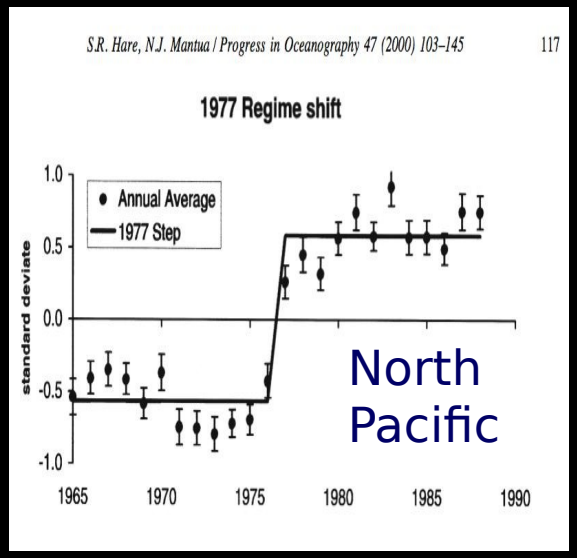
Writing in the journal Proceedings of the National Academy of Sciences (PNAS), the researchers say impacts may be felt as far away as the Arctic.

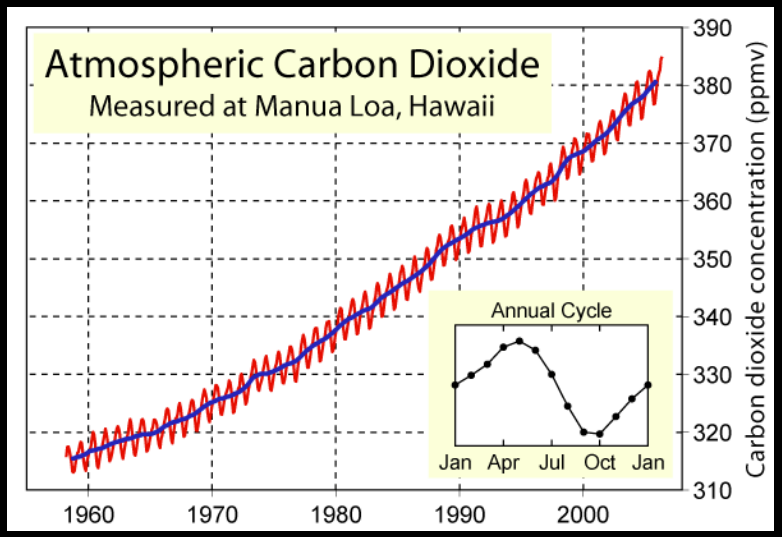
"It's a complex picture," observed study leader Renyi Zhang from Texas A&M University in College Station, US.

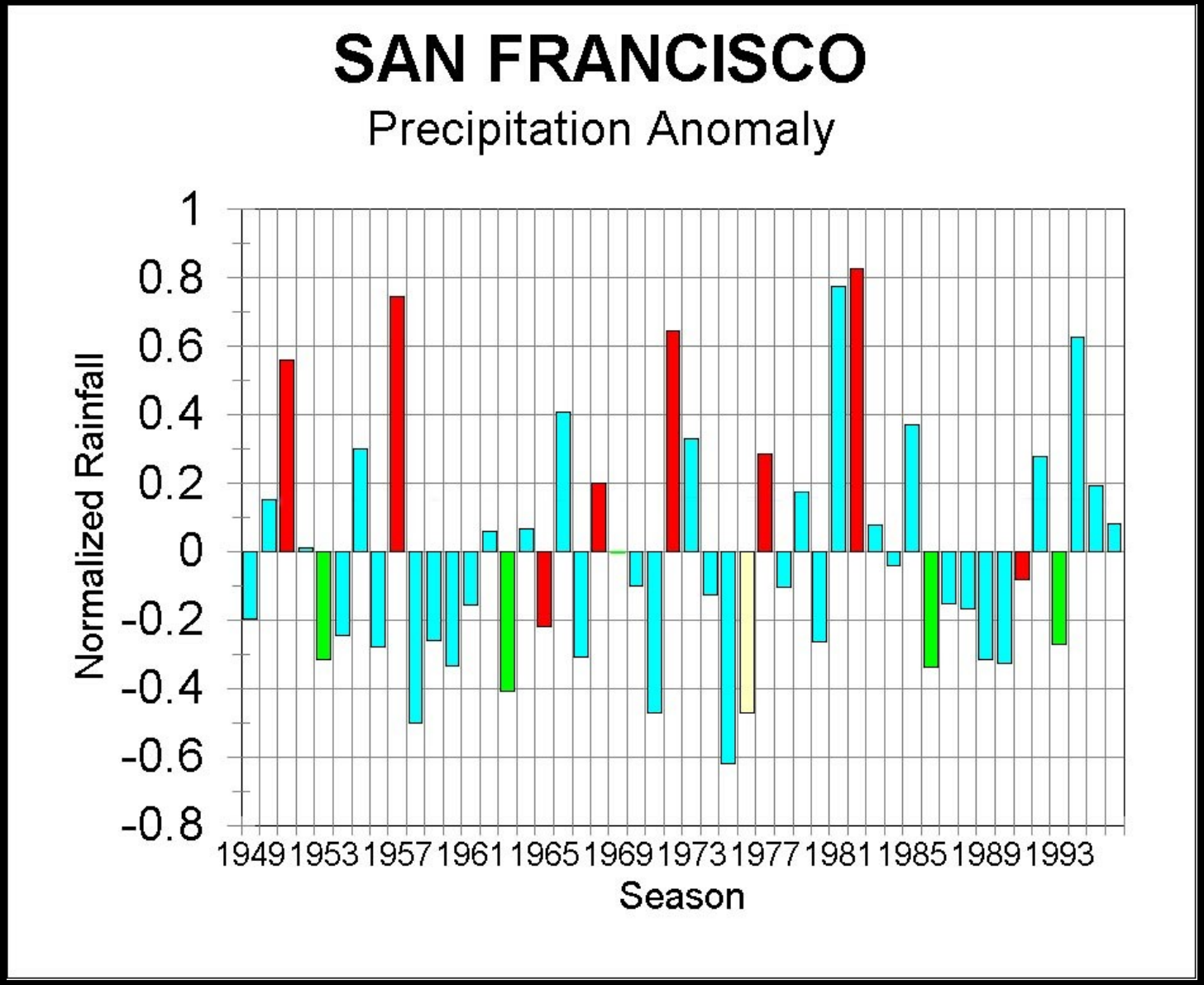
"But the bottom line is that the aerosols actually enhance convection and increase precipitation over a large domain," he told the BBC News website



Alaska is Melting

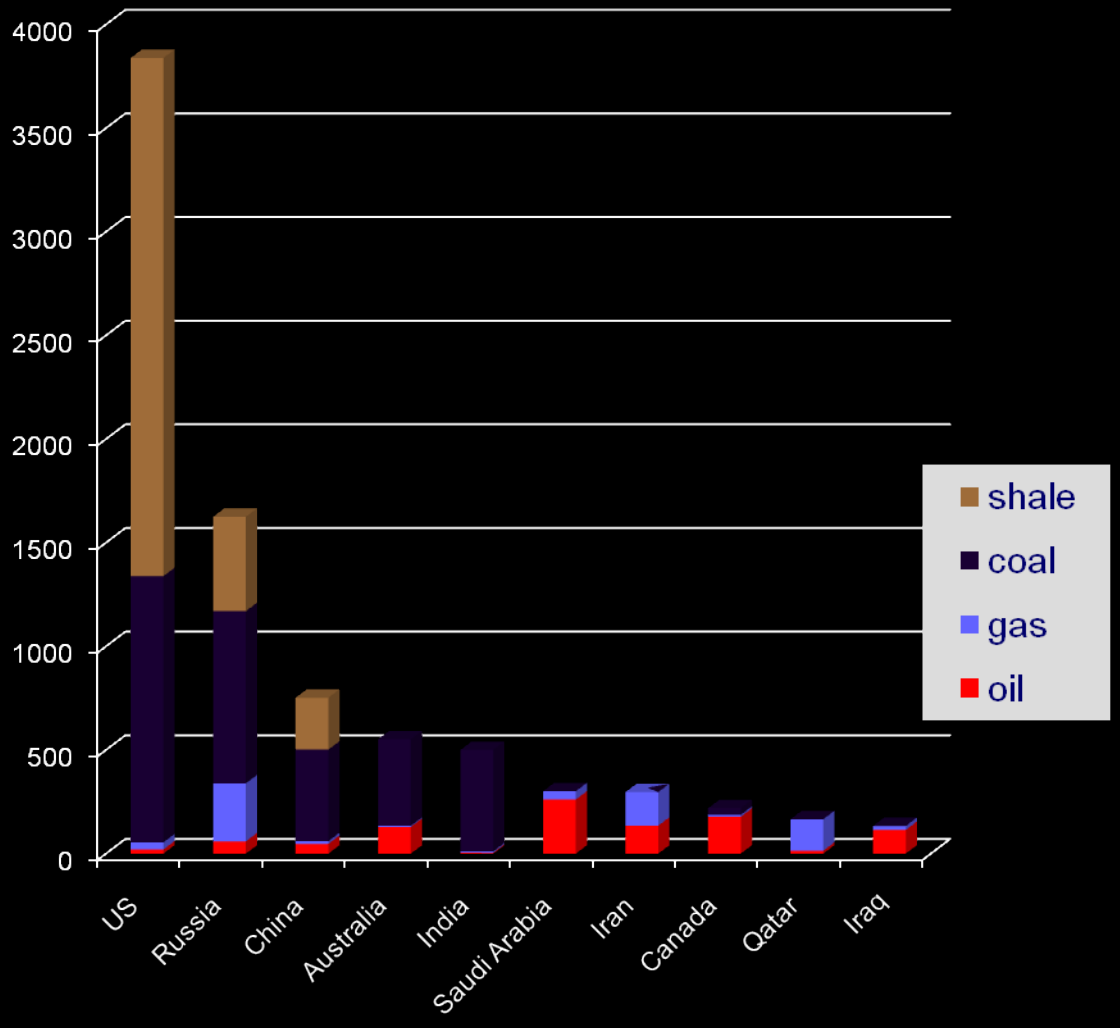





SAN FRANCISCO
Precipitation Anomaly
Normalized Rainfall
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
1949
1953
1957
1961
1965
1969
1973
1977
1981
1985
1989
1993
Season

Fossil Fuel Reserves

(billion barrels of oil equiv)



data:: US Energy Information Agency

Turn Coal into Oil

(CTL – coal to liquid) at about $50/bbl

Fischer-Tropsch

Fossil Fuel Reserves

(billion barrels of oil equiv)

Country	Oil	coal	gas	oil + coal + gas	Total with shale
A	21	1284	34	1339	3839
B	60	831	280	1171	1626
C	48	442	13	503	519
D	130	418	5	553	553
E	5	489	7	502	502
F	262	0	40	302	302
G	136	0	162	298	298
H	179	32	9	220	220
I	15	0	152	167	167
J	115	0	19	134	134

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Mexico	15	.06	2.6	18	18

A Global Warming Skeptic

Disputes the IPCC on both the evidence and on the expected consequences

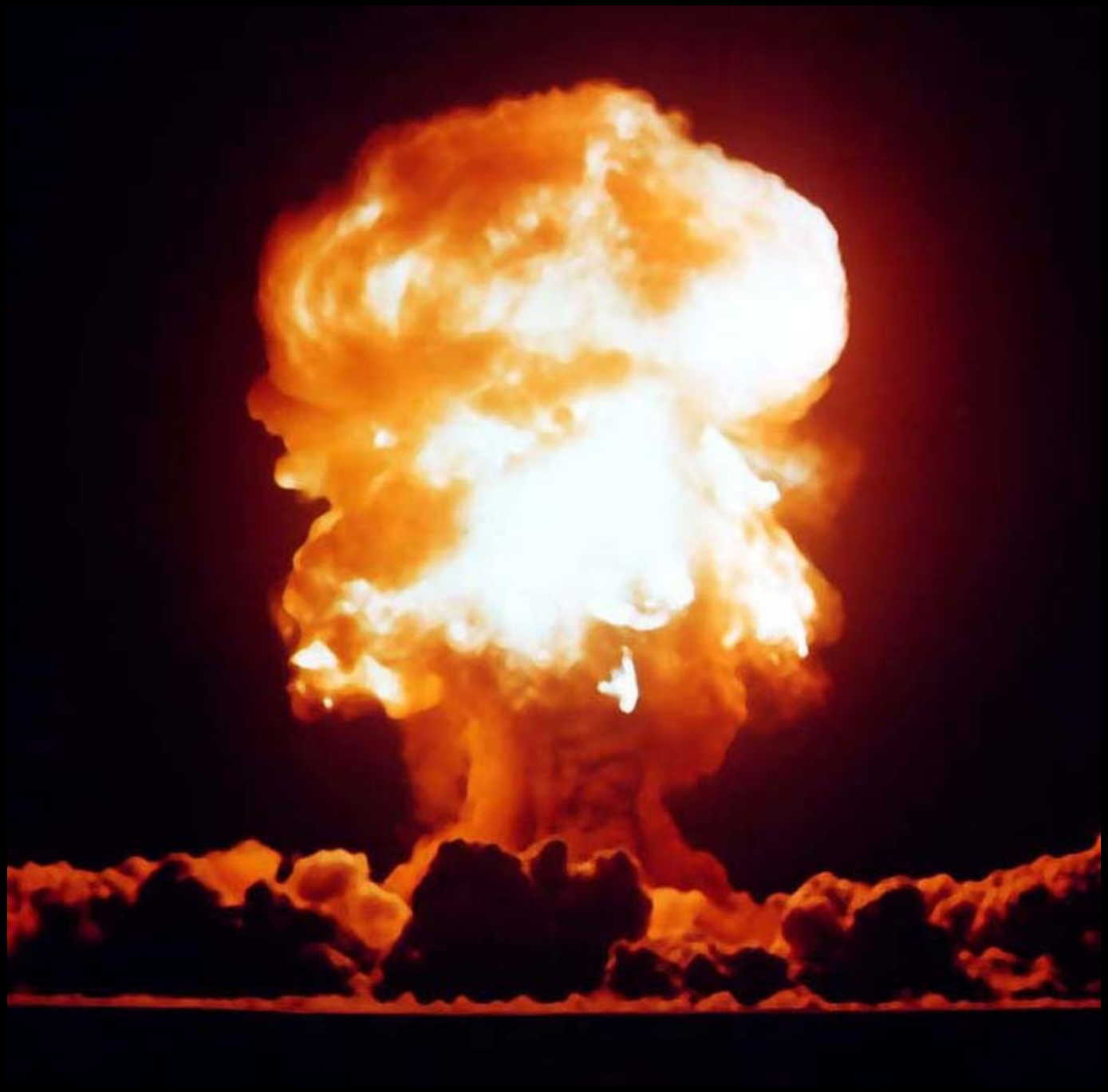
US Cost of energy

($ = US dollars; ¢ = 0.01 US dollar)

fuel	cost	per kWh (1000 Cal)	cost converted to electricity
coal	$80/ton	0.8¢	2.4¢
natural gas	$10/MM-cu-ft	3¢	9¢
gasoline	$4/gal	12¢	48¢
electricity	10¢/kWh	10¢	10¢
computer battery (laptop, Tesla)	$120/lb for 60 Wh 1000 charges	$2	$2.00
advanced Li-Ion (A123?)	$60/lb? 60Wh? 3000 charges?	$0.33?	33¢ ?
AAA battery	$1.50/battery	$1000	$1000

Plug-in Hybrid: more expensive than $15/gallon gasoline!

(but less carbon dioxide)



US Cost of energy

($ = US dollars; ¢ = 0.01 US dollar)

fuel	cost	per kWh (1000 Cal)	cost converted to electricity
coal	$60/ton	0.6¢	2¢
natural gas	$5/MM-cu-ft	1.5¢	5¢
gasoline	$2/gal	6¢	24¢
electricity	10¢/kWh	10¢	10¢
computer battery (laptop, Tesla)	$120/lb for 60 Wh 1000 charges	$2	$2.00
advanced Li-Ion (A123?)	$60/lb? 60Wh? 3000 charges?	$0.33?	33¢ ?
AAA battery	$1.50/battery	$1000	$1000

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Fossil Fuel Reserves
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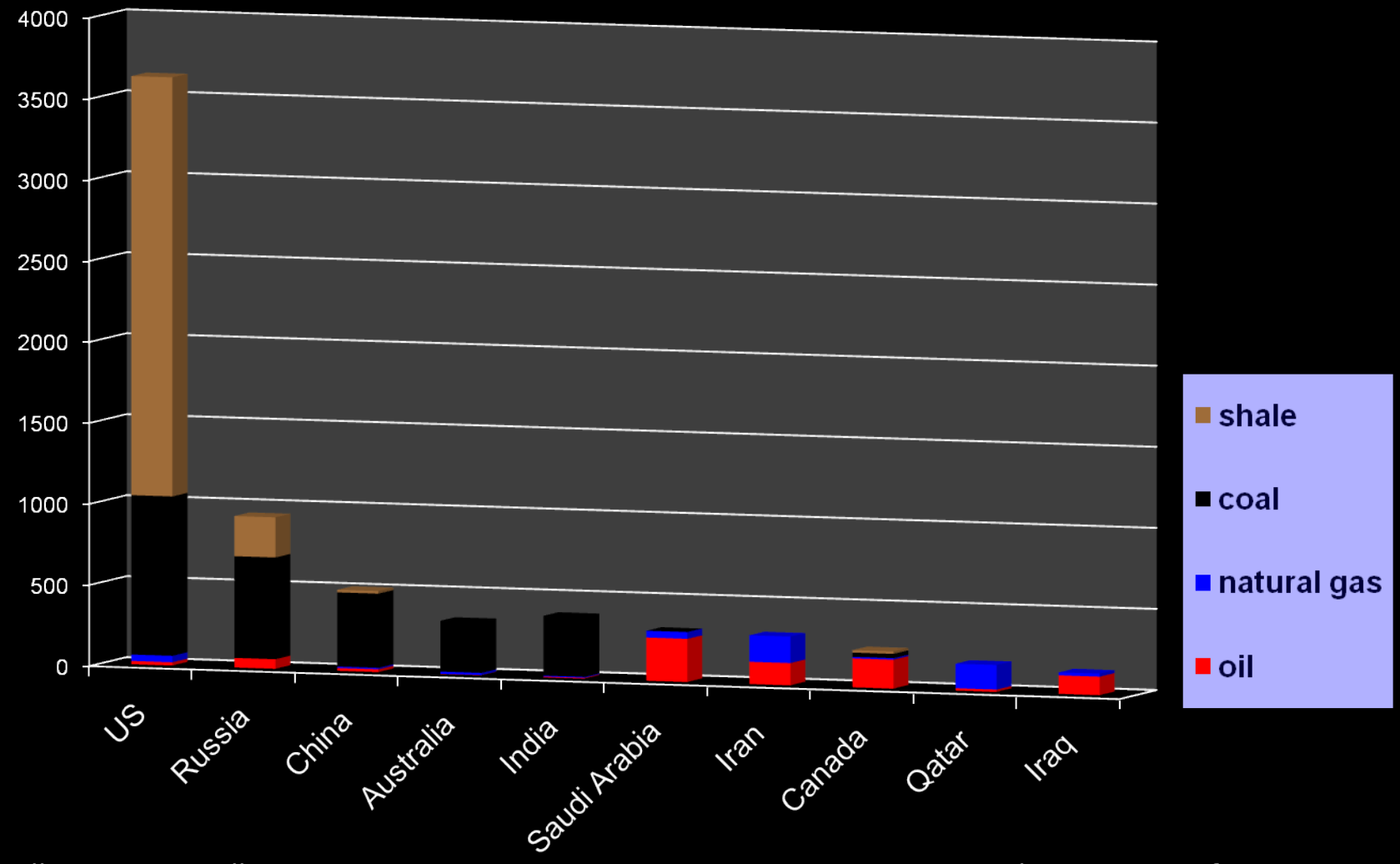
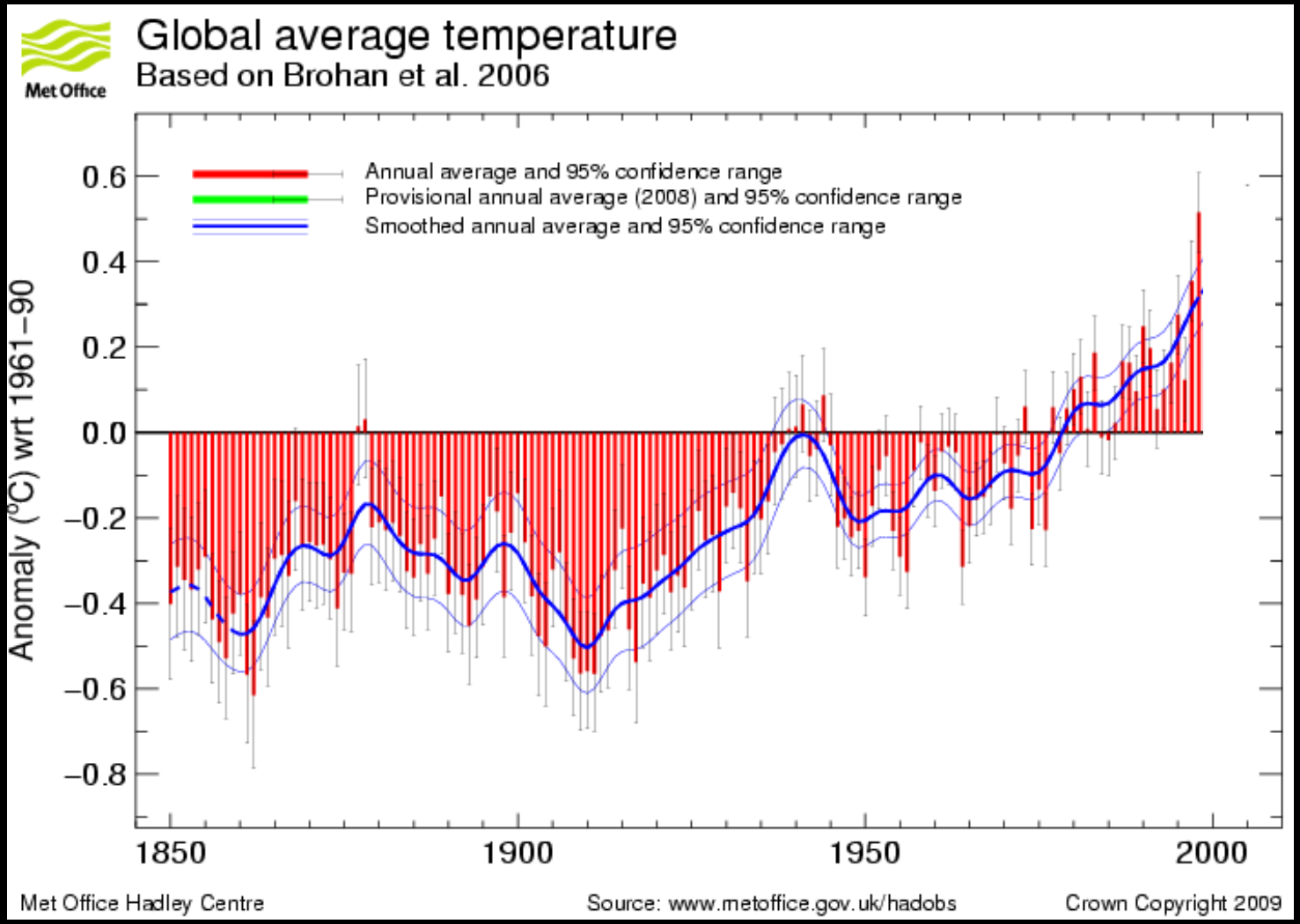


Terrorist Nuke Attack on San Francisco

this 1 kton explosion is greater than the N. Korea test


Met Office
Global average temperature
Based on Brohan et al. 2006
Annual average and 95% confidence range
Provisional annual average (2008) and 95% confidence range
Smoothed annual average and 95% confidence range
Anomaly (°C) wrt 1961–90
0.6
0.4
0.2
0.0
–0.2
–0.4
–0.6
–0.8
1850
1900
1950
2000
Met Office Hadley Centre
Source: www.metoffice.gov.uk/hadobs
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